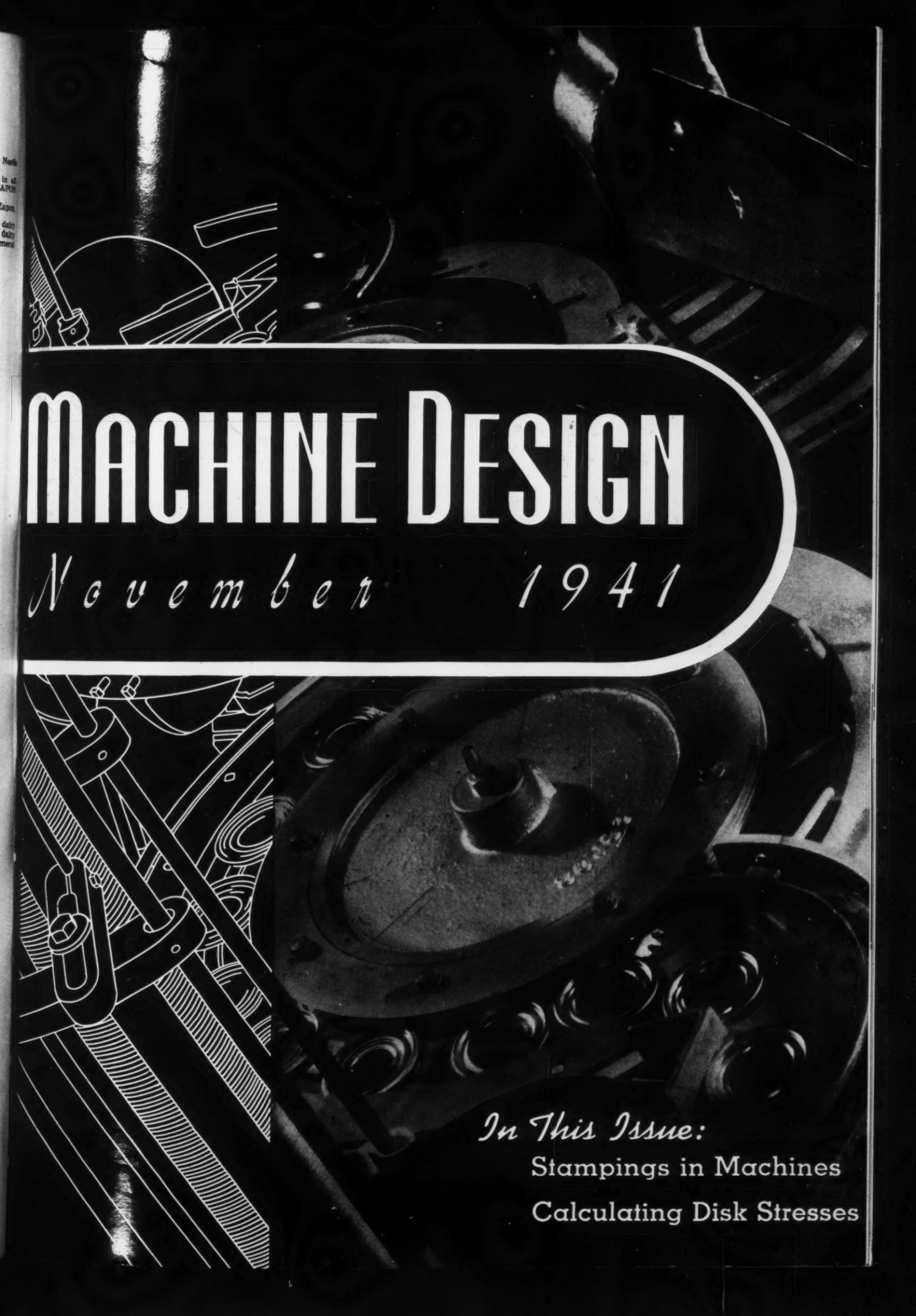


MACHINE DESIGN

November 1941

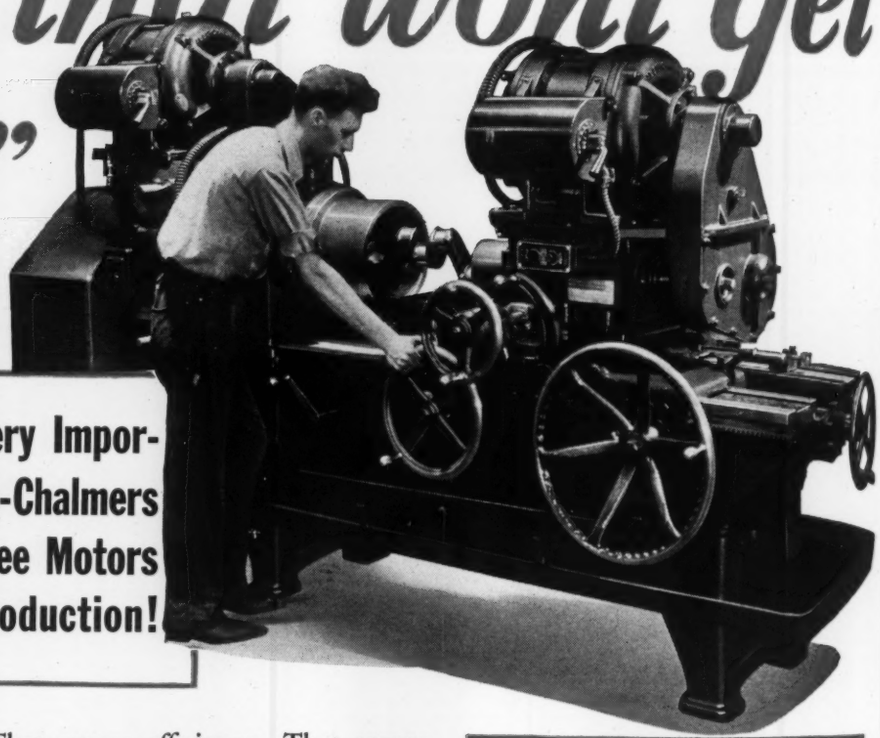
In This Issue:

Stampings in Machines

Calculating Disk Stresses

DEFENSE MACHINES DEMAND

"Motors that won't get tired!"



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When you use Lo-Maintenance Motors you can count on full measure construction — extra value features that insure peak operation: indestructible rotor . . . distortionless stator . . . high carbon steel frame . . . the highest quality in workmanship and materials. No wonder Allis-Chalmers Lo-Maintenance Motors never let you down.

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A 1418

ALLIS-CHALMERS LO-MAINTENANCE MOTORS

A COMPLETE LINE FOR EVERY PURPOSE...ONE-HALF HORSEPOWER AND UP

Keeping Fluid Clean For a Fluid Drive

To keep dirt from the bronze-babbitt and roller bearings of this Fluid Drive Coupling, American Blower Corporation turned to CUNO, the "filter-fine" strainer.

A type G CUNO Auto-Klean Filter, installed in the oil line from the pump to the fluid drive bearings, removes all foreign matter — which in turn is easily cleaned from the filter element without interrupting the flow of oil.

The Hydraulic Coupling illustrated is a Size 48 Variable Speed Fluid Drive made by American Blower Corporation. It transmits power from an aircraft-type engine to an alternating current generator.

WHAT DESIGNERS LIKE ABOUT CUNO

Hydraulic systems and lubricating systems can be provided with completely automatic oil-cleaning by installing continuously-cleanable Cuno. The filter element is cleaned by rotating a handle — manually or automatically — while the fluid continues to flow through the filter. Both adherent and imbedded solids are positively removed.

Compactness is another Cuno advantage, permitting choice of external or internal mounting. (The filter illustrated has an element only 1¼" in diameter by 3¼" long, with .0035" spacing.) And the all-metal, non-collapsible construction insures continuous efficiency throughout the life of the machine.

The filter types and their many applications for filtering oils, gases, water and air, are described in the booklet, "80 Ways to Make More Money." Send for *your* copy — it's free.

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THE "FILTER-FINE" STRAINER

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Topics

RECENTLY, a twin-motored Consolidated Catalina flying boat completed a freak flight by navigating half the Atlantic with both ailerons and one wing tip missing. The mishap was caused by a jamming of the automatic pilot with the starboard aileron full down. Stresses caused by the resulting spiral dive tore away the aileron together with the whole wing tip. With both pilots straining at the manual controls, the other aileron let go and the ship righted itself. In this condition the ship was navigated for the remainder of its journey.

♦

NONFOGGING eyepieces have been developed for gas masks or goggles, consisting of laminated sheet glass and cellulose acetate. This material, on exposure to moist air, is saponified on its surface so that it absorbs moisture.

♦

SEAPLANE floats of resin-bonded plywood recently have been approved by the government. Birch laminations using phenolic resin adhesives make up the floats with coatings of phenolic varnish on the exteriors for resistance to water.

♦

SHORTAGES of tin and aluminum have opened an important field for synthetic lacquers in packaging. Polyvinyl chloride acetate, particularly, has excellent resistance and physical properties for this application.

♦

FUNCTIONING as a clearing house for the engineering professions on information dealing with defense, particularly in relation to shortages and materials savings by improving standards and practices, an Engineers' Defense Board has been created. This new working organization is composed of engineers and technologists from several national engineering socities.

Initial membership consists of five representatives from each society including American Society of Mechanical Engineers, American Institute of Electrical Engineers, Society of Automotive Engineers, American Institute of Chemical Engineers, American Institute of Mining and Metallurgical Engineers, and American Society of Civil Engineers. The new board will assist the various branches of the government with engineering knowledge and experience on questions connected with military preparedness.

♦

INVENTED and developed by Timken Roller Bearing Co., the Assel seamless tube piercing mill has been converted into a shell mill which produces shells twice as fast as the conventional forging methods now in use. Five plants are now in production.

♦

JOINING the ranks of strategic materials, lead is now under full control by the Division of Priorities. Consumption is at the rate of 960,000 tons a year with an appreciable increase anticipated. Current production, including that from foreign ores, is 600,000 tons, the balance being scrap and foreign imports.

♦

SHORTAGES of qualified workers now exist in 126 out of 514 occupations which are essential to defense, according to the Federal Security Agency. These are concentrated in aircraft, shipbuilding, and machine shop trades and include detail and final assemblers, inspectors, riveters, sheet metal workers, machinists, diemakers, etc. Extensive training programs as well as improvements in designs and manufacturing methods can relieve the pressure none too soon.

♦

SYNTHETIC rubber bonded with tiny aluminum fibers is replacing asbestos in Germany for automobile brake linings. The rubber is high temperature resistant Buna and the aluminum reinforcement .03-inch diameter wire. The new lining is also being used on railway equipment.

MACHINE DESIGN

Use Stampings To Conserve Strategic Materials

By Kenneth D. Moslander

DOES the current shortage of materials for machine parts present a serious problem to your engineering department? The answer to that question is almost inevitably yes. Will the stamping of parts from sheet metal afford at least a partial solution to this problem? This question is not as easily answered but the subject of press-formed parts merits careful consideration.

Therefore, the series of articles of which this is the first will present certain criteria to be used as a basis for determining the practicability of making a part of sheet metal or light plate. Further, fundamental rules of "right practice" will be given and illustrated by a number of simple parts, exemplifying the various types of possible press operations.

Shortages are a matter of weight. The annual steel production of 80 million tons is considered inadequate. The emphasis, therefore, is on conserving "pounds" of metal. Stamping will almost certainly achieve this end. By no other method of manufacture can wall thickness be maintained as uniform and such economical use of metal be attained.

Perhaps a component of a linkage system is to be designed. If, to conserve material, a design specifying a stamped and formed sheet steel part is to be developed, a number of basic factors should receive careful study. Among these are: Number of parts required, load to be carried,

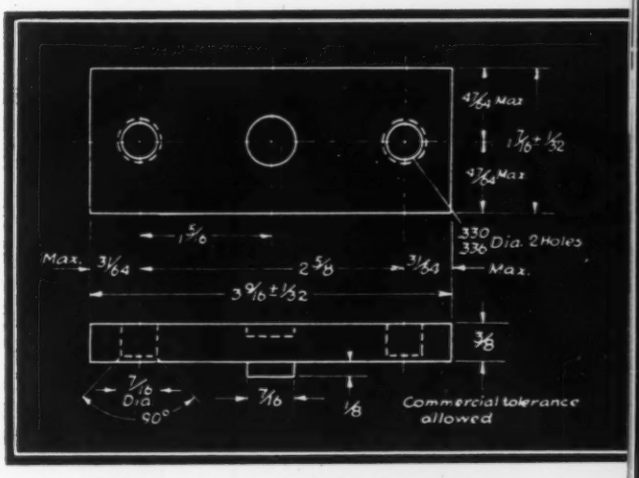


Fig. 1—Tolerances specified for holes in engine insulator plate dictate that they be drilled rather than punched

dimensional limitations in adapting the part to the machine, tolerance limitations on critical dimensions of the part itself, contour, diameter and depth of holes, etc.

In normal times, the decision as to how a part is to be made and the material to be used is ordinarily made on the basis of relative economy. Today,

availability is more important. Scarcity is most acute in the case of so-called decorative metals, chromium, nickel, aluminum, brass, bronze, etc. Less acute is the steel supply and, least of all, steel sheet. Both decorative and functional parts often may be made of low-carbon steel sheet, press-formed, and coated with various available baked enamels, synthetic resins or light platings to attain equally satisfactory results.

Unfortunately the design of stampings is not an exact science. In fact, it is more nearly an art than any other subject in the field of mechanical design. It is clearly impossible for the designer of machines to be thoroughly acquainted with die design and press operation when the stampings companies themselves must, in the final analysis, resort to a method of "cut and try" to produce a finished part.

Professional Consultation Essential

Certain basic rules exist, however, which enable the engineer to carry his design beyond the sketch stage and to appraise the possibilities of the part if made as a stamping. Like all good rules, these are replete with exceptions. However such exceptions are apt to involve failure and are almost sure to be expensive.

The best of all rules, particularly for those inexperienced in designing stampings, is to call in a representative of a stamping producer. Before he arrives lay down only the broadest possible limitations on the part. Indicate several acceptable alternative designs. Above all, do not wait until the rest of the machine is finished. If the advantages of metal stampings are to be realized the stampings producer must be given as nearly a free hand in the design as possible. If a part has to fit in working relationship to a number of others within a couple of thousandths, that cannot be called a free hand.

Strip Stock Would Reduce Cost

Illustrated in *Fig.* 1 is one of the simplest of stampings, a sheared and punched or pierced piece. However it illustrates some commercial limitations. The part is sheared from a long strip ⅛-inch wider than the 3 9/16-inch dimension. This allowance is made because, in shearing the long strip from which the individual blanks are made, it is difficult to control the operation to closer than the ⅛-inch allowance. Hence, even though the comparatively liberal tolerance of ± 1/32-inch is permitted, the short side of the piece is trimmed off when the long side is sheared from the strip.

Of course, if the piece were made from thinner stock which is available in coiled strips of closely held width, the allowance would be unnecessary with consequent saving of material as well as obviating the strip shearing operation. Also, if the tolerance on the 3 9/16-inch dimensions could be increased to ± 1/16-inch, some saving in die cost would be realized because the strip could be sheared to this limit.

Two holes through the piece are drilled and countersunk after the press operations. This is done for two reasons: First, the hole diameters are less than the plate thickness and, second, the diameters of the holes are specified to a total tolerance of .006-inch. The first point introduces a "rule of thumb" which dictates that the diameter of a punched hole must be equal to or greater than the stock thickness in steel; in brass, aluminum, copper, etc. smaller diameters (2/3 of stock thickness) may be specified.

The second point, involving the .006-inch tolerance in ⅜-inch stock, is difficult to attain because of the "breakaway" of a punched hole. Approximately the upper third of a punched hole is sheared cleanly, has a burnished appearance and conforms, in diameter, almost exactly to the diameter of the punch. In the lower two-third of the hole, the breakaway portion, the metal tears away, leaving a rougher surface which tapers slightly outward. It is for this reason that the .006-inch tolerance cannot be held.

If these holes were to be used merely as clearance holes for bolts instead of being tapped for capscrews, material savings could be effected by punching them, thereby eliminating a costly drilling operation.

Center Lug Sheared Through

Used for locating the plate in the final assembly, the center lug is formed by a punch in the same press stroke as the blank shearing operation. Actually, the slug of metal is sheared completely from the plate but the incipient burr in the breakaway portion holds it in place adequately for its intended locating function. Because the metal flows into the plate proper during the punching operation, the punch must penetrate the work from 5/32 to 3/16-inch to produce the specified ⅛-inch lug.

A combination of blanking, piercing and forming operations is illustrated by the mounting bracket in *Fig.* 2. Made of .078-inch hot-rolled steel stock, the blank is stamped and pierced in a single operation. In this case, it will be observed that the size of the holes (11/32-inch diameter) is such that the feasibility of punching them is unquestioned. Complete bending or forming is then a single operation.

Economical use of material is exemplified by the blank shown in the upper right. If an identical blank is cut out, turned over, and placed under the one illustrated, it will be evident how the extension of the upper side fits into the indentation of the lower. In designing a metal stamping it is well to cut from paper developments of the tentative part and analyze them to determine whether or not design alterations are permissible which will

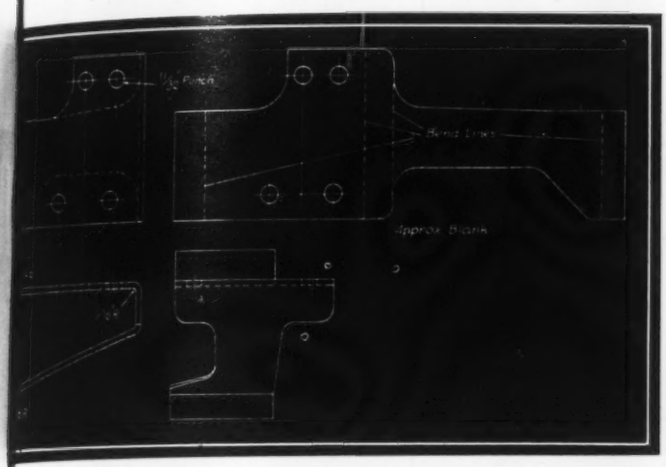


Fig. 2—Despite the fact that the flange bend radii are slightly less than the stock thickness, the flanges are formed in a single operation

result in similar saving of metal.

Location of holes in this bracket is another factor contributing to economy. If holes are pierced in a blank too near a bend line they will be deformed out of round during subsequent forming. A hole edge should be no closer to a bend than the thickness of stock away from the approximate point of tangency of the bend arc to the undeformed, straight section of the material.

Flanges of the bracket shown in the lower left view of *Fig.* 2 indicate the lower limit of radius of bend possible in a simple press operation. Ordinarily this limit can be taken such that the inside radius of the bend is not less than the stock thickness. In this case, it will be noted, the radius is 1/16-inch in .078-inch stock. Sharper corners on the inside would require at least one additional press operation with consequent cost increase. Also, sharp corners on the outside are possible and

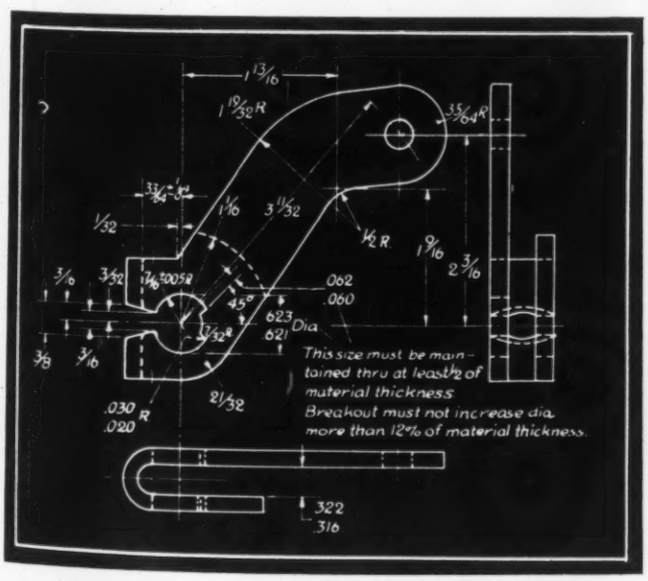


Fig. 3—Machining tolerance and finish of irregular hole in control shaft are attained by shaving operation

are obtained by striking the inside radius with a ridged punch, and then restriking the outside of the bend, upsetting the metal in the bend itself. These additional operations add materially to the cost of the part and should not be specified unless absolutely necessary.

If punched holes were required in the two flanges, further costly complications would be involved. Such holes could not be punched in the blank for two reasons: First, for the reason previously stated, the holes would be too close to the bend to insure against their deformation during flanging; second, insufficient stock would remain outside the holes to permit positive holding of the

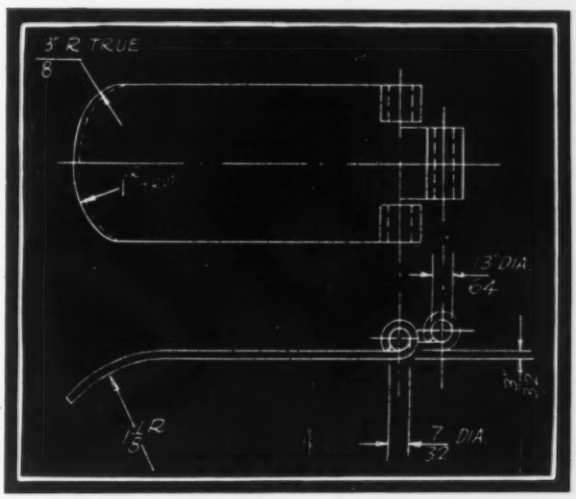


Fig. 4—Curled ends of clasps are formed in one stroke after being started in the blank

blank. Thus, the blank may slip, moving the holes out of location. Therefore, such flange holes would require punching after forming in an additional operation.

Gear shift control-shaft lever, *Fig.* 3, requiring four operations to complete, is an example of the precision attainable at a moderate increase in cost. In this case, a cost increase is more than justified because a part possessing such an end slot and irregularly shaped hole would entail expensive machining if made by any other process.

In the blanking operation, the round hole as well as the two irregularly shaped holes and their interconnecting slots are pierced. The blank is then bent as shown in the elevation. Since the total tolerance on the .322-inch dimension between the sides of the bend is held to .006-inch, a sizing operation must be performed. This consists of restriking the piece over a horn die which is compensated for spring-back of the material.

Again, because of the .002-inch tolerance on the .623-inch lateral dimension of the irregular hole, a shaving operation is necessary. The shaving operation also serves to make the piece conform to the requirements of the two appended notes.

As stated in connection with *Fig.* 1, the breakout portion of the hole is approximately two-thirds

its depth. If, as in this case, a close tolerance is required for a depth in excess of one-third of the total, a similar shaving, broaching or burnishing operation is required. If the higher cost is justified, the entire depth of the hole may be held to equally close tolerances and finish.

Specification of a limit of diameter increase, resulting from breakout, of 12 per cent of the material thickness is also attained only at a sacrifice of low cost. Such a limit is achieved by reducing the clearance between the punch and die. This reduction results in an ironing of the burr which

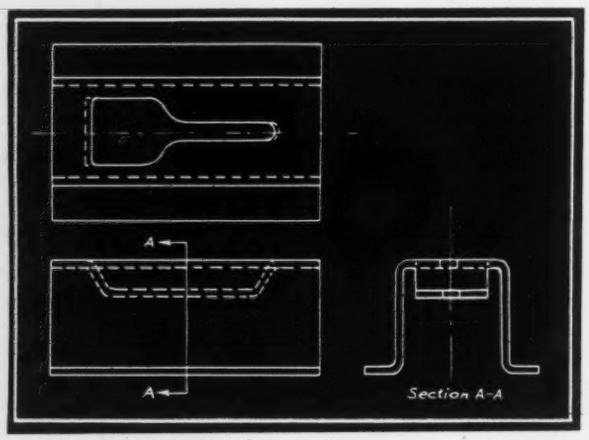


Fig. 5—Formation of slot in hold-down bracket entails a shallow draw plus slitting

starts at the breakaway and detracts greatly from the life of the tools. Short tool life before regrinding is naturally reflected in increased cost of the parts.

A typical curling operation is illustrated by the clasp, *Fig.* 4. While, in this case, the curl fulfills a definite purpose, the same principle of press operation is involved in forming a lip on receptacles of various sorts. Sometimes, where edge reinforcing is desired, the curl is formed around a wire.

Making this clasp requires two operations. In the first, the piece is blanked, formed and the curl started. In the second, the curl is completed by a punch with a semicylindrical face. If it is desired to have the center line of the holes coincide with the plane of the stock, an additional intermediate operation is necessary.

In connection with bend-forming the left hand 1⅛-inch radius, it is well to point out that, because the blank will tend to conform to the contour of the face of the punch, shallow forming operations can sometimes be used together with blanking the piece. When possible, long radius bending and even shallow drawing can be obtained with only nominal increase in tool cost.

Slitting operation entail no removal of metal. In this respect it resembles a scissors cut. The hold-down bracket, *Fig.* 5, is typical of such operations. The large end of the depression in this part is made to receive a bolt head. The bolt shank is then slipped into the narrow slot thereby clamping the part to which the bracket is spot welded at the flanges. The slitting operation and forming the mounting slot is accomplished in one operation. The latter step involves a shallow draw which process will be covered in some detail in the second article of this series to appear in the December issue.

The illustrated bracket is typical of a comparatively low quantity production job in that three operations are performed: shearing to size, forming channel, and both slitting and forming the mounting slot.

If a considerably larger number of pieces are required, a reduced cost per piece may be realized by the use of progressive dies. In this case the parts would be made from a long strip of stock. The cut-off and forming operation could be combined in one and slitting and forming in a second.

No general rule can be stated as to the minimum number of parts which would justify the use of the more expensive progressive dies. For that matter, the minimum number of parts which can be economically made by stamping conforms to no definite rule. These factors depend upon the design of the part, the cost of alternative methods of manufacture, the degree of precision required, the material of which it is made, and the service for

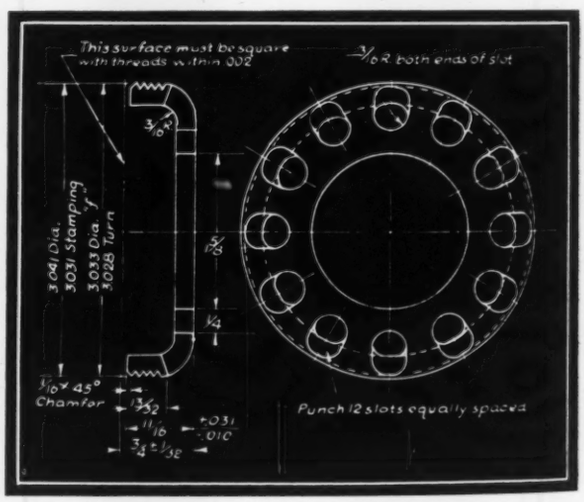


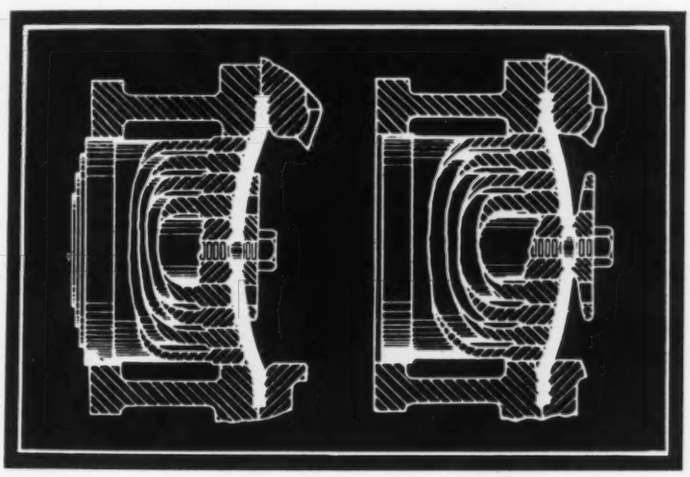
Fig. 6—Oval holes punched in blank deform to approximate roundness in drawing

which it is intended. Such considerations constitute another reason why a stamping representative should be called into consultation in the early stages of the design. In the final design of a stamped part there is no substitute for experience and only the stamping manufacturer possesses the experience necessary to give reliable opinions on these two factors.

Normal deformation of holes pierced in the blank in or close to a bend or corner radius is

(*Continued on Page* 124)

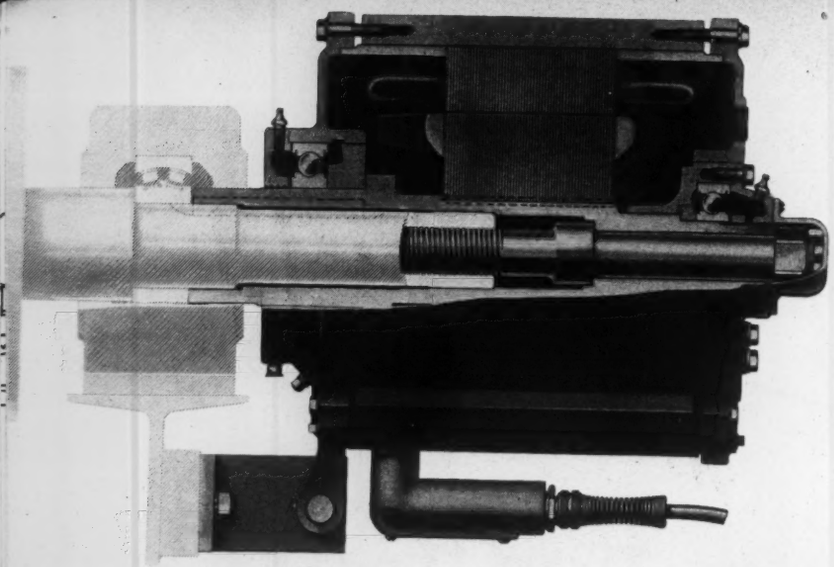
Scanning the Field FOR IDEAS



Concentric rings, each mechanically actuated to produce a different length of stroke, combine the advantages of diaphragm and positive-displacement pumps in the design developed by T. Shriver and Co., illustrated at left. A double-acting piston pump, the pistons or concentric rings are cam actuated in such a manner that the inner ring has the greatest travel. Thus the diaphragm of neoprene or other impervious material constitutes a positive displacement unit, forming convex and concave spherical surfaces at opposite ends of travel. Operating parts are in a bath of oil, the diaphragm forming a seal between unit and pumping chamber.

Spring bars shown in the frame at right are utilized to eliminate practically all the troublesome "double frequency" vibration associated with two-pole generator units. Vibrations, both radial and tangential, are effectively absorbed in these low period bars in the frame designed by General Electric Co.

Twin sets of spring bars are attached to the frame, three for each dovetail key-bar. Spring bars are welded at each end between frame ribs and have two bolts through the middle of each pair. The key-bars, then are bolted at these points with suitable spacers to allow the required amplitude for damping. Thus a resilient mounting is provided between the core laminations which are stacked on the key-bars and clamped securely by an end plate.

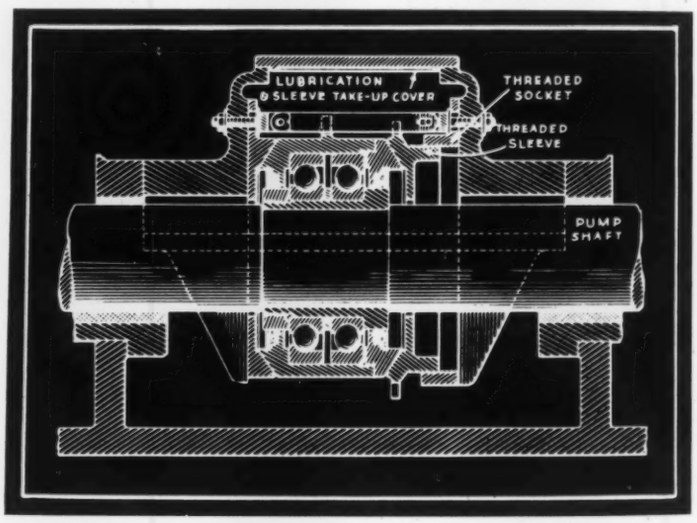


Built-on motors for steel mill tables shown in the sectional illustration above have most of the advantages of shell-type motors as well as possess the availability and easy maintenance of standard motors applied in the usual ways. Designed by Reliance Electric and Engineering Co., the motor is overhung in a novel manner. Entirely supported by the roll bearing with a quill bearing supporting the left end of the motor frame, the rotor functions as an integral part of the roll. This precludes any possibility of misalignment due to roll sagging, etc.

The motor frame, being positioned by the motor bearings, has a simple, resilient mounting consisting of a lug with a helical spring on each side retained by a through pin and bracket anchored on the table bed. These springs cushion the starting of the motor, absorb shock loads, and compensate for misalignment.

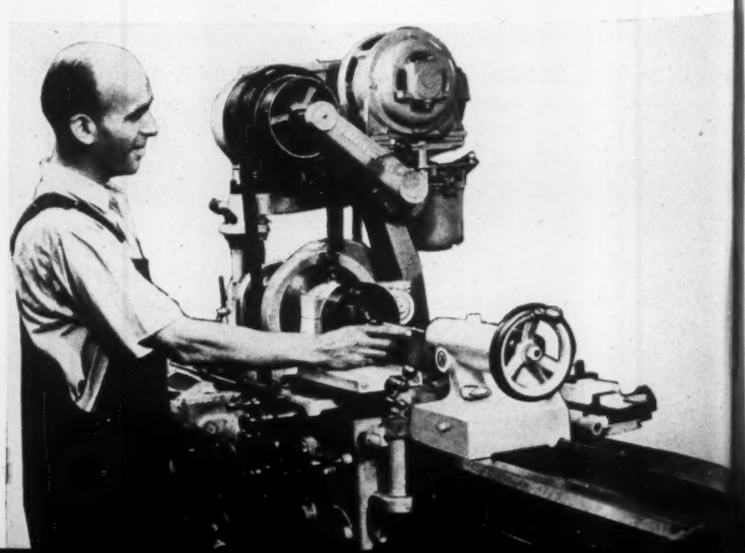
Mounting and dismantling are readily effected. The completely assembled motor is drawn on the roller shaft by a pinned nut on a central bolt shown in the illustration. When the bolt is turned in the opposite direction a shoulder on the bolt forces the whole motor off the shaft extension.

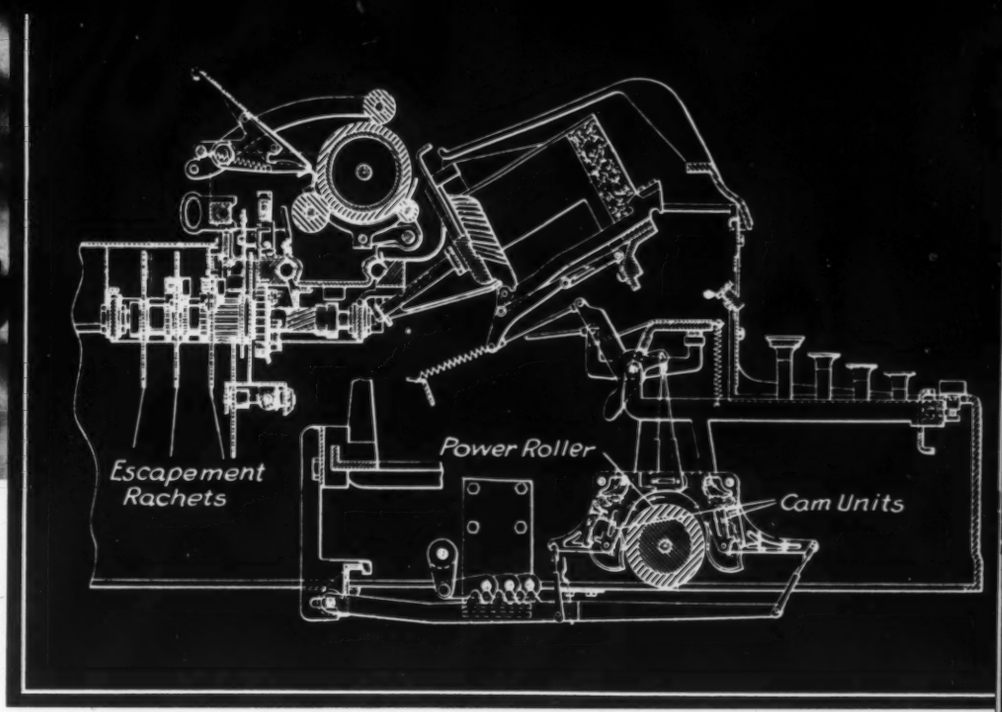
Simple adjustment and alignment are incorporated in this bearing at right, designed by the American Brake Shoe and Foundry Co. The alignment feature is provided by the spherical surfaces on the outer cartridge faces and the adjustment by a threaded sleeve and socket arrangement, the latter being readily accessible through an opening with a hinged cover. Lubricated separately from the sleeves, the unit is not subject to contamination from the oil which may come through the sleeve bearings.



Effect of color in the design of machines is recognized as important both from the standpoint of appearance and increased, better quality production. Recently, psychological surveys made by E. I. du Pont de Nemours Co. showed that for the lathe at right a "spotlight" buff at working areas and "horizon" gray on the machine body increased operating efficiency and that workers reacted more favorably to this pleasing combination than to other colors tested. Accident hazard is also reduced through proper color selection by increasing the visibility of moving parts by "spotlighting" with color or by silhouetting against a background.

For maintenance considerations, the body of the machine is painted gray instead of the whole machine being light buff. The combination, however, is better than any solid color, based on the results of the surveys. Light gray is another useful color and light blues also have possibilities.

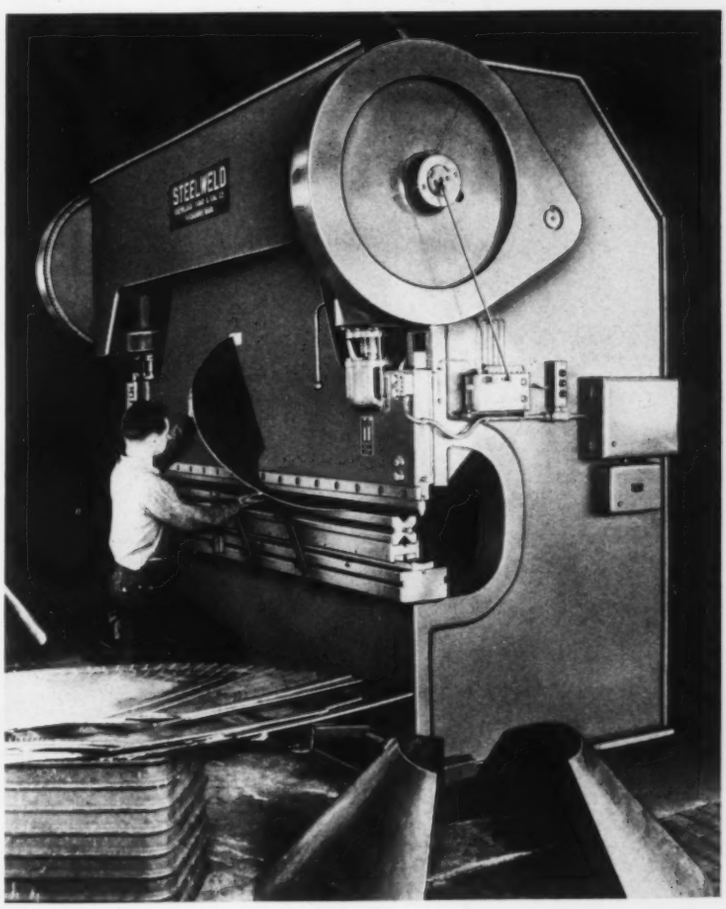




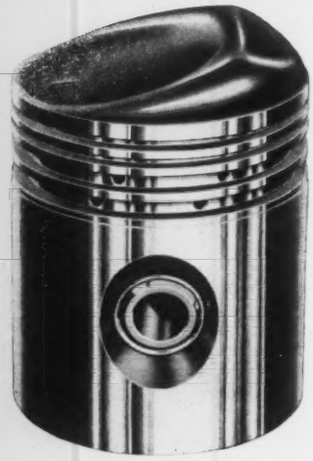
Refinements in office machines are indicative of the more exacting standards now required generally. Typical are recent typewriter developments providing proportional spacing for various widths of characters and justification of lines to make them of equal length, as characterized by the newly announced machine developed by the International Business Machines Corp.

Proportional spacing is obtained through three escapement ratchets which provide seven variations in spacing. Being a power operated machine, depressing a key trips a cam unit against a rotating roller. This movement causes the proper key bar to strike the platen and selects the spacing to fit the character width. Selection mechanism consists of linkages allowing movement of the desired combination of escapement ratchets. These linkages are also associated with the shift mechanism for varying the spacing between capitals and lower case characters.

Back spacing is power operated by the rotating roller, previously mentioned. A single lobe cam unit, together with bell crank and linkages, operates the wide-faced ratchet at the right of the escapement ratchets in the drawing. The arbitrary unit of back-spacing chosen is two units or, for a standard machine, .022-inch. Correction for proper position may then be made by advancing the carriage by one or the other of two space bars which spaces either two or three units.



Tapering adjustment on ram of the bending press at right enables forming of conical sections and other varied shapes without the use of special dies. Developed by Cleveland Crane and Engineering Co., the tapering mechanism is extremely simple. Operation of ball-handle lever in front of the ram disengages the clutch, permitting operation of right-hand screw only. The ram swivels on trunnions in the slides so there is no cramping on guides or bearings.



Metallurgists Rescue th94

BY SHOULDERING a defense load which by the end of the year will exceed five billion dollars the nation's automobile industry has accepted a herculean task as its first responsibility. However, the customary introduction of new car models this fall, although lacking some of the usual fanfare, has proceeded on schedule. With respect to appearance, the new models generally are a distinct advance beyond the 1941 concepts.

Principal mechanical changes are in the direction of transmissions extension of the liquid-clutch-plus-semiautomatic-gearshift principle to additional lines, including Studebaker, Lincoln and Mercury. This type of transmission is being continued by Chrysler, Dodge and De Soto, while Oldsmobile and Cadillac expect even greater demand from buyers for their fully automatic transmission.

Fig. 1—Above—Typical of aluminum conservation is Buick's new cam-ground tubular-type alloy iron piston. Fig. 2—Below—Greatest opportunity for conserving zinc is in its replacement by stampings

Noteworthy for 1942 cars is the critical materials situation. Selection of alternate and optional irons, steels, alloys and nonmetallics to fill the breech where demands of defense have pre-empted supplies of strategic materials normally used in automobiles. That the industry's engineers and metallurgists have been able to accomplish the switch in record time is a tribute to their ability.

First, considering metals, those upon which defense authorities have placed mandatory priority are: Aluminum, magnesium, zinc, tungsten, nickel, copper, chromium, lead, vanadium, iron and steel—each used to some extent in automobiles. The problem has been to get along with less or none of each. Taking each separately, the plan worked out by engineers of General Motors as explained by A. L.

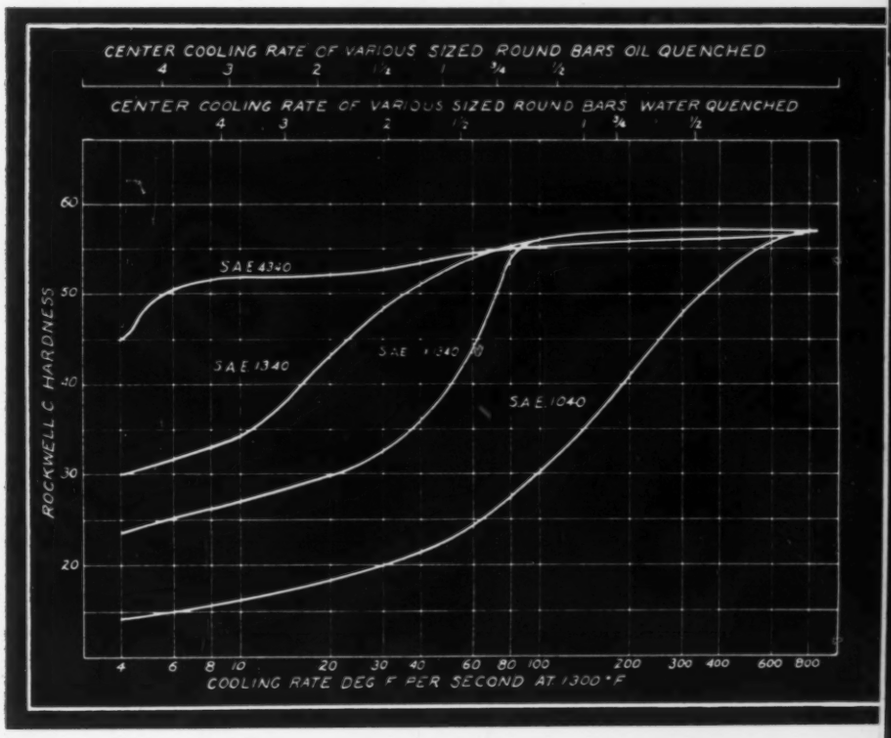
CONSERVATION of materials for defense is having its inevitable effect on the automobile industry. This article, prepared by A. H. Allen, Detroit editor of MACHINE DESIGN, is based on a paper by A. L. Boegehold, head of the metallurgy department of General Motors Research Laboratories, supplemented by information from other sources

Boegehold, head of the metallurgy department of General Motors Research Laboratories, is:

ALUMINUM: Principal use has been in pistons, for both engines and brake cylinders. Pontiac and Chevrolet, being standardized on cast iron pistons, were in a better position than Buick, Olds and Cadillac who several years ago adopted aluminum alloy pistons in the interests of more power resulting from higher compression ratios and of reduced bearing loads resulting from less weight in reciprocating parts.

Changing back to cast iron pistons requires adjustments and changes in design because, with respect to aluminum, cast iron pistons are heavier by 50-85 per cent, their thermal conductivity is less than one-half and their coefficient of expansion about one-half. Degree of changes necessitated varies depending upon the design of the engine. Connecting rods may be slightly heavier, or heat treated to higher physical properties; piston clearances will be less (a desirable change incidentally); piston pins may require slight increase in size to

Fig. 3—Comparison of the manner in which the hardness produced by different cooling rates is affected by the alloy content of steel


CENTER COOLING RATE OF VARIOUS SIZED ROUND BARS OIL QUENCHED
4 3 2 1½ 1 ¾ ½
CENTER COOLING RATE OF VARIOUS SIZED ROUND BARS WATER QUENCHED
4 3 2 1½ 1 ¾ ½
ROCKWELL C HARDNESS
60
50
40
30
20
SAE 4340
SAE 1340
SAE 1040
4 6 8 10 20 30 40 60 80 100 200 300 400 600 800
COOLING RATE DEG F PER SECOND AT 1300°F

accommodate heavier loads; and crankshaft counterbalance weights may require modification.

Another factor which made the use of lighter aluminum alloy pistons desirable at the time of their inception was the unsatisfactory performance of main and connecting rod bearings. Now, however, bearings have been improved to the point where they are not a determining factor in choice of pistons.

Pearlitic malleable iron is being used for pistons by Oldsmobile. High strength permits thinner sections and hence are lower in weight than plain gray cast iron. The pearlitic malleable piston weighs 24 ounces, replacing an aluminum piston weighing 16 ounces and comparing with a gray iron piston weighing 31 ounces. This change to iron from aluminum, incidentally, results in additional cost per car in spite of the use of a lower cost material, the increase being due solely to greater tooling and machining costs.

For replacement of die-cast aluminum brake cylinder pistons, much research and testing led to a final choice of a steel stamping coated with tin. This stamping is low in cost because of ease of manufacture, provides ample strength and, with the tin coating, has adequate frictional properties and resistance to corrosion. Another satisfactory type of piston utilizes powdered iron compressed accurately to size, sintered and then tin plated.

Zinc Can Be Virtually Eliminated

Other former uses of aluminum include: Rocker arm shaft brackets where a change to cast iron gives equal performance and durability; direction switch housing in the steering wheel hub where cast iron, plastic or drawn steel are satisfactory alternates; and in zinc die castings, this to be discussed under the heading of zinc.

ZINC: Die castings, both decorative and structural constitute the principal uses of zinc. TABLE I lists some typical automotive die castings together with materials which are being used to replace them. If necessary, it is possible to work out alternate materials so that virtually complete elimination of zinc from the motor car is possible. One such possible substitution is in front grilles, *Fig.* 2. It is believed, however, that by eliminating a major share enough metal will be available so that such parts as carburetors can be continued in zinc.

Use of zinc-base die castings involves the consumption of an additional amount of aluminum which comprises 4 per cent of the alloy. As Mr. Boegehold points out, this aluminum has been used because it reduced dross due to solution of iron from the melting pot and also improved physical properties and castability of the alloy. Satisfactory alloys from the standpoint of service may be used, with only 1.5 per cent aluminum, the 4 per cent alloy being required only for those castings which are of such shape that sound castings cannot be made with the lower-aluminum alloy.

One other extensive use of zinc is as a constituent in brass for radiators. At first it was thought advisable to change to straight copper instead of the 70-30 copper-zinc alloy, but, since copper was becoming increasingly critical the industry was advised to return to brass for radiators. Copper and zinc both being critical metals, it appears that if automobiles are to be built at all, enough of these metals must remain available for radiators.

TIN: While tin is not affected by priorities as yet,

it is a "strategic" metal because it is imported principally from the East Indies. Automobile uses include main and connecting rod bearings, bronze bushings, piston coating, radiator solder, body solder, terne plate for gas tanks and mufflers, and tin foil in condensers. In bearings of certain General Motors lines, tin has been reduced by perfection of thin lead-base babbitt containing 3-4 per cent tin, reinforced by a copper-nickel sponge bonded to a steel back. Approval has been given to the small amount of nickel involved because of the consequent savings in tin and aluminum.

Little opportunity exists to replace the 4-10 per cent tin required in bronze piston pin bushings to maintain resistance to scoring and high-temperature corrosion.

Coatings Reduce Amount of Tin

Oxide coatings formed by steam at elevated temperatures, phosphate coating deposited from an aqueous solution, or an electrodeposited tin-lead coating eliminate or reduce to a minute amount the tin necessary for coating cast-iron pistons to improve frictional properties.

Radiator solder contains 10 per cent tin. It can be replaced with 95-5 lead-silver or lead-calcium solders. Body solder is 75-25 lead-tin and is now needed only in small amounts as the technique of assembling body panels has been improved. Terne plate is not used for mufflers in all cars, some still being black steel sheet. Coating on terne plate is 92-8 lead-tin and it is expected that sufficient quantities will continue to be available for gasoline tanks. Tin foil for condensers can be replaced with lead foil containing a small amount of tin.

COPPER-NICKEL-CHROMIUM (for plating): Former practice of plating trim parts with .0003-inch copper, then .0007-inch nickel and finally .00001-inch chromium has been revised to reduce the nickel layer to around .0002-inch by increasing copper to .0008-inch, without sacrificing protection against corrosion. For plated parts on body interiors it is possible to eliminate the nickel coat entirely, plating chromium directly on copper. However, with copper now covered by priority regulations and being required in steadily increasing amounts for defense purposes, prospects are for a fairly complete elimination of plating and bright work from automobiles when present stocks of plated parts are exhausted, which will be in January according to present estimates.

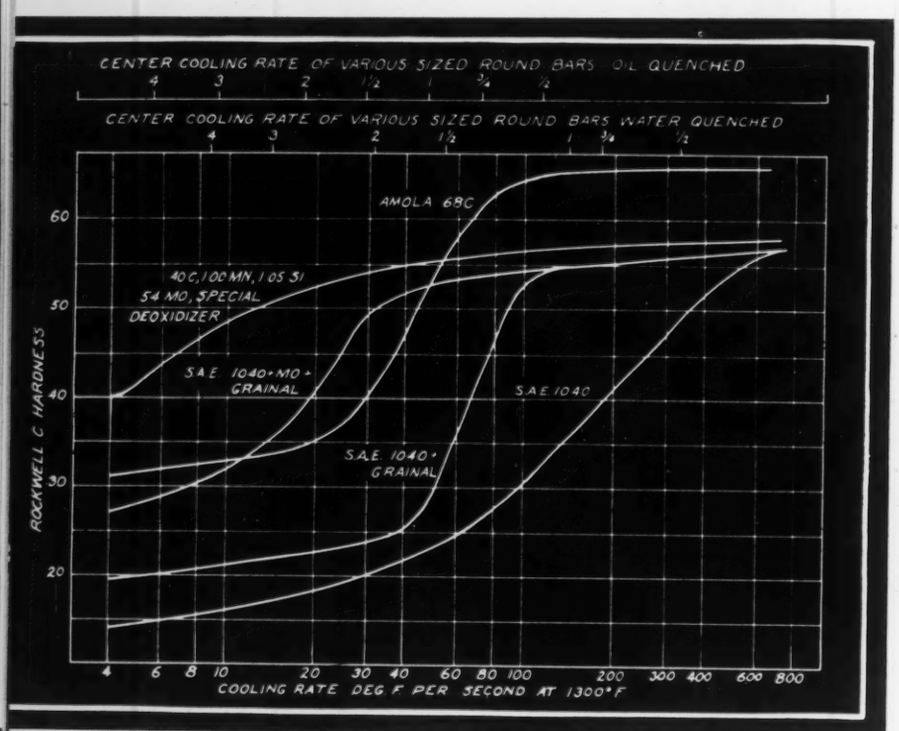
In connection with these forthcoming changes, R. H. McCarroll, metallurgist, Ford Motor Co., makes some pertinent observations. He says, "We have classified in one group 19 decorative parts which seem sure to be changed. They are:

1. Reveal, belt, hood, running board, fender, windshield backwindow and weatherstrip moldings
2. Wheel rings
3. Headlamp doors and retainers
4. Windshield retainer
5. Ventilator window and division bar
6. Rear lamp and rear lamp ornament
7. Trip plate
8. Parking lamps
9. Glove box trim
10. Instrument cluster trim
11. Hood ornament
12. Radiator grille-frame assemblies, side grilles and center grille
13. Clock and speedometer bezels
14. License plate lamp body
15. Handle and lock assembly, luggage compartment door
16. Horn ring
17. Hood medallion
18. Radio grille center
19. Ventilator window regulator handles.

"Six additional bright decorative parts we have listed as functional as well as decorative are:

1. Bumper bars
2. Bumper guards
3. License plate guard
4. Inside door handles
5. Outside door handles
6. Hub caps.

"We hope to keep these last six as bright chromium plated parts because of needed durability and safety. Elimination of plating on the others will give a reduction of 58 per cent in chromium as well as in copper and nickel. Nickel on Fords has been reduced from 2.07 to .57 pounds per car since March. All primary aluminum has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4 3 2 1½ 1 ¾ ½
CENTER COOLING RATE OF VARIOUS SIZED ROUND BARS WATER QUENCHED
4 3 2 1½ 1 ¾ ½
AMOLA 68C
40C, 100 MN, 1 05 SI
54 MO, SPECIAL DEOXIDIZER
S.A.E. 1040+MO+ GRAINAL
S.A.E. 1040
S.A.E. 1040+ GRAINAL
ROCKWELL C HARDNESS
60
50
40
30
20
4 6 8 10 20 30 40 60 80 100 200 300 400 600 800
COOLING RATE DEG. F. PER SECOND AT 1300°F

Fig. 4—Newly developed low alloy steels have satisfactory hardenability for replacing steels in Fig .3

Fig. 5—Rapid development of plastics makes them strategically available for replacing metals in both decorative and operating parts

been eliminated and the amount of zinc per car reduced from 35 pounds to 23.1 pounds."

On the basis of present changes, and assuming Ford could produce the same number of units in 1942 that were produced in 1941 (which of course cannot be done) there would be released for defense purposes 1,700,000 pounds of primary aluminum; 2,000,000 pounds of secondary aluminum; 2,500,000 pounds of nickel; 12,000,000 pounds of zinc; 500,000 pounds of tin and 500,000 pounds of magnesium.

CHROMIUM-NICKEL-MANGANESE (in steels): Stringency of nickel and chromium has militated against use of either the straight-chromium or chromium-nickel stainless steels for decorative purposes (after present stocks are exhausted, as explained previously). In steels used to resist heat corrosion, such as for exhaust valves, no adequate substitution for chromium is seen. Valve steels now in use contain up to 24 per cent chromium and 5 per cent nickel for Oldsmobile; 22 chromium and 2 nickel for Chevrolet, Pontiac and Buick; and 21 chromium and 12 nickel for Cadillac. According to Mr. Boegehold's analysis, steels with lower chromium, such as those with 8.5 per cent chromium and 3.5 silicon, are generally unsatisfactory in this application.

Requires No Nickel for Exhaust Valves

On Ford exhaust valves, which have required nickel, Mr. McCarroll cites how co-operation between metallurgists and engineers led to the development of a new analysis without any nickel, which proved to be equally serviceable with a slight increase in the angle under the head and addition of some stock to the top surface of the valve.

Nickel and chromium now being controlled by priorities and the definite prospect of a limit of 1 per cent manganese in alloy steels for nondefense purposes, the question may well be asked: How is it possible to obtain a steel strong enough to take place of alloy steels which have been used?

Mr. Boegehold probes this question and points out that the principal reason for the use of alloys as nickel, chromium and manganese beyond one per cent, is to make steels which will harden properly when used in large sections.

Plain carbon steel, for example, hardened and properly tempered, is just as good as alloy steel in many cases. Thus, valve springs are made from high-carbon steel without any alloy other than manganese, an ingredient of all carbon steels. Plain carbon steel in small pieces, such as valve springs can be hardened properly because small pieces cool rapidly when quenched in oil. No advantage would result from the use of nickel, chromium or other expensive alloys.

In a part such as a steering knuckle or a transmission gear cluster, carbon steels will not harden properly because such heavy sections do not cool fast enough in quenching in oil or water. If designers and metallurgists were restricted entirely to plain carbon steels, they indeed would be on the spot. The remark is heard frequently that parts must be larger to withstand loads if made of carbon steels. Such a course would only make matters worse for, by increasing the size of the part, still less through-hardening would be possible.

Hardness is synonymous with strength. An alloy steel and a plain carbon steel of the same hardness both have the same strength or load-carrying ability. However, since plain carbon steel will not harden in the majority of the important parts of an automobile, there must be steels which will harden properly even though the use of nickel, chromium and manganese beyond one per cent is denied. Thanks to increased knowledge of alloys it is now possible to duplicate the hardening power of any of the present highly alloyed chrome-nickel-manganese steels without the use of these elements except the manganese used in plain carbon steel.

Still available are manganese up to one per cent;

(*Continued on Page* 98)

TABLE I

Alternate Materials for Zinc Die Castings

Zinc alloy die cast parts	Alternate materials
Radiator grilles	Plated steel stampings
Instrument board grilles	Plated steel stampings or cellulose acetate plastics
Radiator ornaments	Antimonial lead die castings or steel stampings with transparent plastics
Lamp bodies	Steel stampings
Fender trim strips	Antimonial lead die castings or chromium plated strip steels
License brackets	Cold rolled steels
Horn projectors	Steel stampings
Horns	Lead-base die castings or steel stampings
Speedometer gears	Powdered iron, or machined steel
Steering wheel hubs and brackets	Steel stampings or malleable iron castings
Shock absorber guides	Cast iron
Transmission covers	Cast iron or steel stampings
Carburetors	Cast iron with zinc die casting inserts for main discharge nozzles
Door handles	Plated steel stampings, or plastics (inside) or combinations of steel and plastics

Designing Controlled Power Hyd

By Christian E. Grosser

CONTROLLED power hydraulic transmissions are well exemplified by their common application to constant tension reels where the effective reel diameter varies by reason of the accumulation of stock. In the preceding article* of this series the characteristics of the controlled torque hydraulic circuits were discussed and attention called to their usefulness in similar service for operations such as wire drawing, metal sheet and strip rolling, paper rolling, and certain take-up or pay-off reeling operations.

Constant stock-tension, however, is obtained by constant torque application only if the stock is pulled by a rotating member of constant radius, such as a reducing roll in a rolling mill or a bull head in a wire drawing stand. Substantially constant tension may be obtained in a reeling operation if the outer radius of the reel bundle does not change too greatly between the empty reel and fully built up bundle of stock.

It is evident from an inspection of *Fig.* 1 which illustrates a simple take-up reel for drawing out strip stock from a processing machine, that if the radii R_1 and R_2 (representing the initial and final winding position of the stock) are much different, the stock tension will vary considerably in the process of building up a coil under the application of constant torque to the reel drive. When the reel is empty the radius R_1 from which the stock is being pulled is short. Hence a given torque applied to the reel shaft will produce a tension F_1 such that $F_1 = T/R_1$. When the reel is full assuming that the radius $R_2 = 2R_1$ and that the reel driving torque T is unchanged, the stock tension F_2 has changed to

$$F_2 = \frac{T}{R_2} = \frac{T}{2R_1} = \frac{1}{2}F_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

It is not unusual for reeled wire, flat stock, etc. to have outside diameters over twice the inside. Since the tension under which such stocks are drawn through processing machinery often affects the size and quality of the finished product, it is important to control the reeling tensions within closer limits than may be realized with commonly used torque type reeling equipment. A much used reel drive device is the slipping friction clutch which produces a more or less constant torque but may not be depended upon to give constant reeling tension. Torque type electric motor drives have similar limitations. In instances where fine wire stock, fragile or elastic yarns are being reeled, the difficulties of breakage, stretching, and bundle overlapping caused by variable tension become serious handicaps to production. The same considerations apply to pay-off reel operations, such as in wire cable and rope twisting, in which each strand fed from a bundle is supposed to be laid in under the same tension.

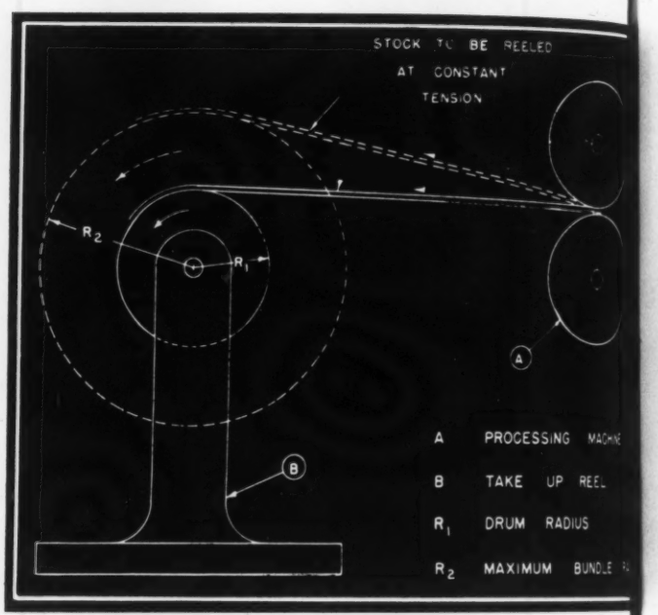

Fig. 1—Variation in effective reel diameter caused by the accumulation of strip stock requires a controlled power motor to maintain constant tension

If the stock moves at a constant speed to a take-up reel, which is usually the case, the necessary condition for constant tension is that the reel drive supply constant power to the reel shaft. This may be proved as follows:

$$\text{Power} = \text{force} \times \text{velocity} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$= \text{stock tension} \times \text{stock speed} \quad \ldots\ldots (3)$$

and if the power is constant, having some value C_1, and the speed is constant, having a value C_2, then from Equation 3,

$$C_1 = \text{stock tension} \times C_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

and stock tension $= C_1/C_2 =$ constant.

*"Designing for Hydraulic Torque Control," MACHINE DESIGN, Sept. 1941.

Hydraulic Circuits

This is further demonstrated by observing in *Fig.* 1 that with a constant stock speed the rotational speed N of the reel reduces as the radius of the bundle R_2 increases, in the relationship

$$\text{Linear stock speed} = 2\pi N_1 R_1 = 2\pi N_2 R_2 = C_2 \quad \ldots (5)$$

But the torque is equal to the bundle radius multiplied by the stock tension,

$$\text{Torque}_1 = \text{stock tension}_1 \times R_1 \quad \ldots (6)$$
$$\text{Torque}_2 = \text{stock tension}_2 \times R_2 \quad \ldots (7)$$

Now multiplying by $2\pi N$ in each equation

$$2\pi N_1 \text{Torque}_1 = \text{stock tension}_1 \times 2\pi R_1 N_1 \quad \ldots (8)$$

and

$$2\pi N_2 \text{Torque}_2 = \text{stock tension}_2 \times 2\pi R_2 N_2 \quad \ldots (9)$$

But the left side of each equation is equal to the power, which is assumed to be constant with value C_1. Also from Equation 5

$$2\pi R_1 N_1 = 2\pi R_2 N_2 = C_2 \quad \ldots (10)$$

Now substituting C_2 for its values in Equations 8 and 9

$$\text{Stock tension}_1 = \text{stock tension}_2 = C_1/C_2 \quad \ldots (11)$$

which is a constant if the reel power and stock speed are constant.

There are other drive applications in addition to the constant tension reel for which constant horsepower is desirable. Various forms of hoisting machinery, such as windlasses, cranes, elevators, oil well drill hoists, using a variable speed drive with constant horsepower control may utilize the full power of their prime movers during the major portion of their acceleration periods. Consequently they are enabled to reach full hoisting speed in a minimum time. Also, the raising of light loads may be accomplished more quickly than heavy loads, the time being in inverse proportion to the magnitude of the load. Another potential field of application is in traction drives for automotive equipment to replace the mechanical change gear transmission.

Torque-Speed Function Is Hyperbolic

Direct-current electric motor drives of the series-wound type are familiar examples of constant-horsepower equipment used in practically all the applications mentioned above. It has been pointed out in previous articles of this series how the characteristics of displacement type liquid transmissions closely resemble those of direct-current power machinery. In this article, some constant-horsepower hydraulic circuits will be discussed which behave much the same as the series motor drives and may, under certain circumstances, be used in their stead to advantage.

In instances where direct current is not available, the hydraulic drive, in combination with a constant-speed alternating-current motor, gives equivalent service. When direct current must be generated from an alternating-current source, the hydraulic circuit will be found somewhat lower in cost and size than the corresponding direct-current, generator-motor circuit and its controllers.

Behavior of a constant power source under variable speed conditions is shown graphically in *Fig.* 2. The relationship, torque $\times$ speed $=$ constant, is shown as a portion of a hyperbola limited by the maximum torque capacity of the drive and by its maximum speed. The range of speed variation is normally at least 2:1, the ratio of maximum to minimum speed. Within the limits of practical design, it may be as high as 4:1 in both electrical and hydraulic drives of this kind. The ratio of maximum to minimum torques is clearly the same as that for the correspondng speed range.

Illustrated in *Fig.* 5 is one form of constant-power circuit employing a variable-displacement hydraulic pump driven by a constant-speed prime mover and supplying a flow of liquid to a constant-displacement fluid motor. This is a conventional form of variable-speed transmission as described in the article on controlled speed transmission† with the addition of an automatic pressure responsive

†"Designing for Hydraulic Variable Speed," MACHINE DESIGN, July 1941.

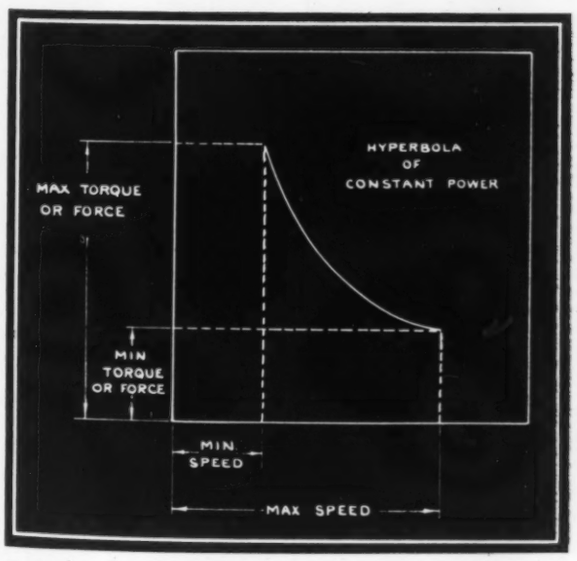

Fig. 2—Constant product of torque and speed produced by constant power hydraulic motor results in hyperbolic function of constant power

displacement control, or stroke control, on the variable pump. This control serves to regulate the flow of oil from the pump in such a way as to maintain approximately the relationship

$$Q_p(P_{po}-P_{pi}) = \text{constant} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

where Q_p = oil flow delivered by the pump, P_{po} = oil pressure at pump discharge, and P_{pi} = oil pressure at pump intake.

Equation 12 will be recognized as being the equivalent of hydraulic power delivered by the pump and equal to a constant.

Actually the displacement control is responsive only to P_{po}, the pump discharge pressure, and neglects to take into account variations in P_{pi}. But, since the magnitude of P_{pi}, pump intake pressure, is nearly always small compared to P_{po}, this effect is negligible. Therefore, from Equation 12

$$Q_p \times P_{po} = \text{constant (approximately)} \quad \ldots\ldots\ldots (13)$$

It will be recalled from the previous discussions of the variable speed transmission that the pump stroke control position governs the delivery of oil from the pump according to the relationship

$$Q_p = S_p D_p N_p \left(1 - \frac{Q_{Lp}}{S_p N_p D_p}\right) \quad \ldots\ldots\ldots\ldots\ldots (14)$$

where

Q_p = flow rate from pump
S_p = stroke, or fraction of full displacement of pump
D_p = full displacement per revolution of the pump
N_p = pump shaft speed
Q_{Lp} = internal leakage rate, usually a function of the pressures P_{po} and P_{pi}.

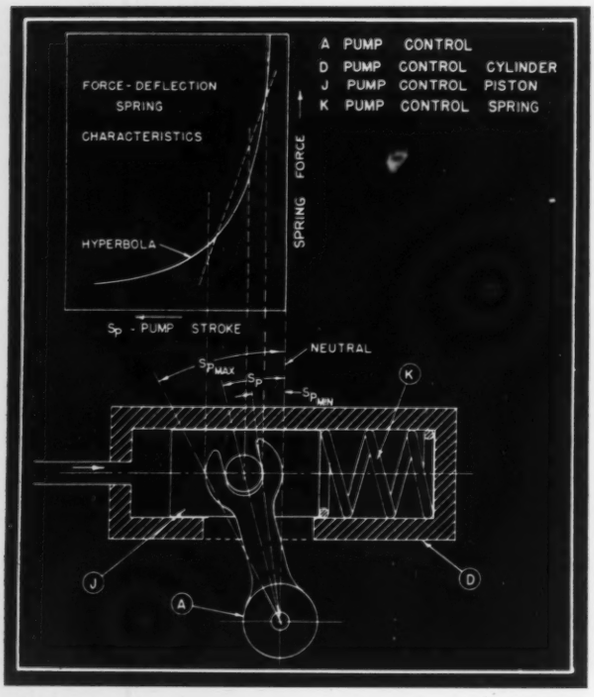

Fig. 3—Automatic pressure responsive stroke control for pump controls oil flow to adjust torque-speed relationship for constant power

The quantity in brackets in Equation 14 which is the volumetric efficiency of the pump, may be taken as approximately constant over the working range of pressures in constant-power operation since it will vary by only a few per cent. Also N_p, the pump shaft speed, will vary but little. Accepting these approximations and keeping in mind that D_p is constant Equation 14 may be written

$$Q_p = S_p \times \text{constant} \quad \ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Substituting this value of Q_p in Equation 13 gives

$$S_p \times P_{po} = \text{constant (approximately)} \quad \ldots\ldots\ldots (16)$$

for constant power delivery from the pump.

The pump displacement control maintains this relationship as follows: The control pressure line transmits the pump discharge pressure to the pump control cylinder where it acts on the pump control piston. Opposing the movement of the control piston is a spring which is designed to hold the piston (and the attached pump control arm) to a value of S_p as prescribed by Equation 16. In other words, for high values of pump pressure, P_{po}, the pump stroke, S_p, is reduced by moving against the spring force and, at low pressures, the spring moves the stroke control to a higher value of S_p with a consequent larger flow of fluid from the pump.

Delivers Constant Power

How the pump-control piston motion and spring force are related is shown graphically in *Fig.* 3. The curve of spring force (equivalent to the oil pressure over the piston area) versus the control position, S_p, is a hyperbola, being the relationship in Equation 16. Actually the spring force-displacement characteristic is a straight line (shown dotted in *Fig.* 3) which is designed to lie close to the correct curve over the operating range of stroke.

Having established that the pump in *Fig.* 5 delivers substantially constant hydraulic power to the fluid motor, and neglecting the small variations in efficiency of the connecting lines and fluid motor, it follows that the fluid motor will deliver substantially constant power at its output shaft over a range of speeds. At low speeds the output torque is high and at higher speeds the torque is decreased in inverse proportion.

In considering the design of the constant power displacement control for the pump of *Fig.* 5, it is necessary to point out that the acting force of the stroke control spring must be several times as large as the resistance of the pump stroke-control lever. This control resistance is a variable quantity and differs for the various types of variable-displacement pumps. An accurate measurement of the control resistance under all conditions of stroke and pressure is necessary for such design. The spring force must be balanced by the appropriate piston area multiplied by the corresponding pressure for a given stroke displacement as determined by Equation 16. The larger the spring force, the more accurate will be the response of the control to changes

in the operating speeds and torques. The throttle valve in the control pressure line in *Fig.* 5 serves to stabilize the control by damping out oscillations or "hunting." Too much damping by this valve is to be avoided, however, since it has a tendency to render the control sluggish in operation.

A disadvantage of the circuit in *Fig.* 5 is that the control spring K must be changed to control the value of power transmitted.

Another form of constant-power circuit is shown in *Fig.* 4. This circuit employs a constant-displacement pump supplying pressure to a variable-displacement fluid motor. The circuit is identical with a conventional variable-speed transmission as illustrated in a previous article† on controlled-speed transmissions with the exception of the special power-controlling stroke control on the variable-displacement fluid motor. It is in many respects a better design than *Fig.* 5 in that practically no variations in transmission efficiency enter into its operation. Thus it may accurately supply output torques and speeds to satisfy the constant power relationships of *Fig.* 2. Furthermore, its operation is stable, the motor stroke control involves no complicated design considerations, and the amount of power to which the circuit is set may be easily changed within the entire range by the simple adjustment of a bleed valve.

Delivered Power Is Constant

Referring to *Fig.* 4, it may be noted that the constant-displacement pump supplies a constant flow of oil to the fluid motor, under the assumption that the pump is driven at constant speed. If the pressures in the lines between the pump and motor are unchanging, the hydraulic power delivered to the fluid motor will be absolutely constant. This statement involves no approximations since the pump and line efficiencies remain unchanged if the pressure and flow are unchanged. On the further assumption that the fluid motor efficiency does not vary, it should be clear that it will deliver constant power at its output shaft under all conditions of speed and torque within its range of operation. Actually the fluid-motor torque efficiency will change slightly over the speed range but its effect is so small as to be negligible. The volumetric efficiency changes not at all if the oil pressure is constant.

Delivery of constant power to the fluid motor, however, is dependent upon maintenance of constant pressure in the lines. This is accomplished by the bleed valve shown in *Fig.* 4 connecting the control pressure line with the pump discharge line. This bleed valve is a form of spring-loaded relief valve which is set to open at a given pressure in the pump discharge line. If the pressure in the line rises above the set value, oil flows through the control pressure line into the pump stroke control cylinder and moves it against the spring to increase the stroke of the fluid motor. This, of course, increases the effective motor displacement per revolution so

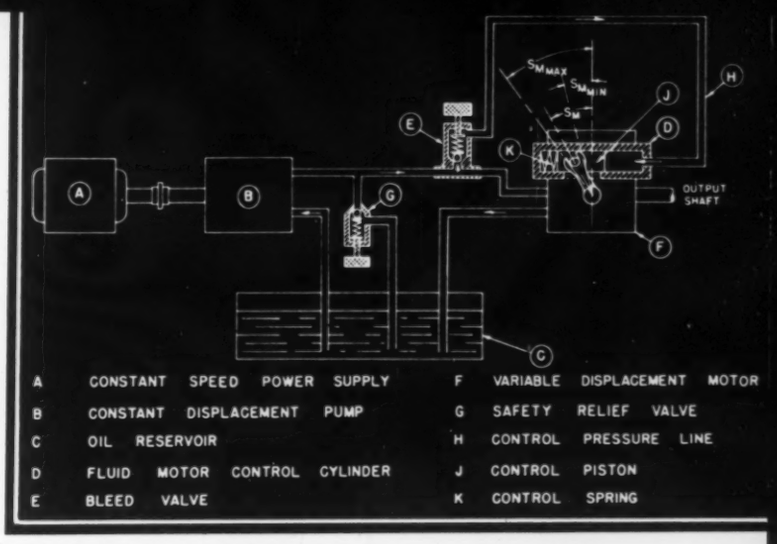

Fig. 4—Circuit is identical with conventional variable speed transmission except for the addition of a stroke control on the fluid motor

that the motor output torque is increased and the output speed is decreased in inverse proportion, thereby maintaining the constant power output.

If, on the other hand, the pressure in the pump discharge line falls below the bleed valve setting, the bleed valve closes. Then leakage past the control piston permits oil to flow from the control cylinder. The control spring then moves the stroke lever to a smaller motor stroke setting. This decreases the effective displacement per revolution of the fluid motor so that it exerts a lower output torque and its output speed rises in inverse proportion to the torque. Again the change in operation has been such as to maintain constant output power. Actually, except under sudden changes in load, the bleed valve remains open slightly and permits a continuous small flow of oil to the control cylinder with just sufficient pressure to keep the piston compressed against the spring in the correct stroke position. This oil leaks past the control piston.

Of course if the torque load on the output shaft increases beyond the point where the fluid motor can accommodate it by increasing displacement per revolution, the pressure in the pump discharge line will rise and blow off the safety relief valve. At this point constant horsepower is lost since one limit of operation has been reached.

Stop Prevents Speed Increase

As the torque load decreases on the output shaft the output speed increases by the action of the stroke control. When the rated speed of the machine is reached, a stop on the stroke level prevents further speed increase and so the torque load is permitted to fall off beyond this point without maintaining constant horsepower. This then is the other limit of operation.

The operation of the control system of *Fig.* 4 may by studied from another viewpoint by the equations

$$T_m = \frac{(P_{mi} - P_{mo}) D_m S_m}{2\pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

$$N_m = \frac{Q_m - Q_{l.m}}{D_m S_m} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$$

where the following symbols apply:

T_m = torque on the fluid motor shaft in inch pounds
D_m = displacement per revolution of the fluid motor in cubic inches
S_m = fraction of full stroke setting
N_m = output shaft speed in revolutions per minute
P_{mi} = motor intake pressure in pounds per square inch
P_{mo} = motor exhaust pressure in pounds per square inch
Q_m = flow entering the pump in cubic inches per minute
Q_{Lm} = leakage in the pump in cubic inches per minute.

If the load torque T_m rises, the first reaction from Equation 17 is a slight increase in P_{mi} which reacts on the stroke control to increase S_m, the

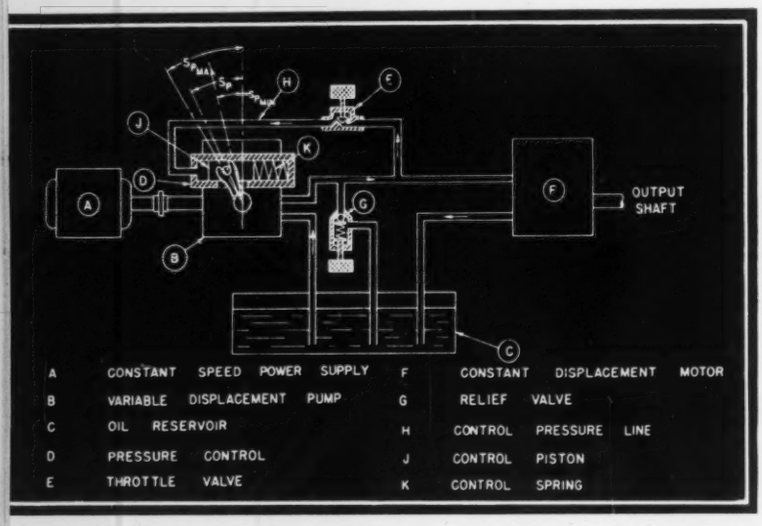

Fig. 5—Regulated by pressure control, substantially constant power is supplied by pump to the fluid motor and hence to the output shaft

stroke, restoring P_{mi} to its previous value. But the increase in S_m is seen in Equation 18 to produce a reduction in N_m, the output speed.

Design of the spring K in the stroke control of *Fig.* 4 simply requires that its force be large enough to overcome the control lever resistance and accelerate the stroking mechanism rapidly enough to respond quickly to load conditions. The control piston must have sufficient area to overcome the control spring and control resistance with as small a fraction of the lowest operating pressure P_{mi}, as is practical.

Sizes of pumps and motors in constant-horsepower operation under the circuit in *Fig.* 5 must be selected on the basis that their manufacturer's ratings for maximum power be as many times as large as the maximum power to be transmitted (under constant power) as the ratio of maximum to minimum output speeds in the operating range. In the circuit of *Fig.* 4, the above rule for selection applies to the fluid motor but not to the constant displacement pump which may transmit the full manufacturer's rating under constant power operation.

Rolls on Its Nose

EXTRA traction provided by track-type drive for army scout cars is utilized for extricating these vehicles from shell holes and other depressions. Instead of the customary flat steel bumper on the front of the car, a heavy spring-loaded roller is used. This roller is mounted with its axis horizontal and perpendicular to the longitudinal center line of the vehicle. The forward element of the roller extends well in front of the headlights, fenders and other parts. Also a plane tangent to both the roller and the front wheels does not intersect any part of the car.

Hence when the front end drops into a hole the drive from the rear tread induces a transfer of the load from the front wheels to the roller. Thus the car literally "rolls on its nose" up and out of the far side of the depression.

Marking a distinct advance in the design of mobile military equipment the treads of the track-type rear drive are rubber, greatly facilitating its travel over paved roads and detracting nothing from its movement overland in difficult terrain. Rubber is bonded to steel plates attached to forged or stamped steel links which are then, by appropriate fastening means, joined together to form the continuous tread.

Made by the Autocar Co. the trucks are produced by advanced mass production technique. Two pro-

duction lines are used, one for the bodies and the other for the chassis. In the plant layout for the assembling operation the engineers have provided for installing these lines on separate floors. At the end of the body line this component is lowered through a hole and fitted on the complete chassis after which the unit rolls off the line under its own power. Whereas actual production figures are not available, large numbers of these cars, mounting two .30 caliber and one .50 caliber machine guns and used as a prime mover for the 105 millimeter howitzers have been produced in the course of the last four months.

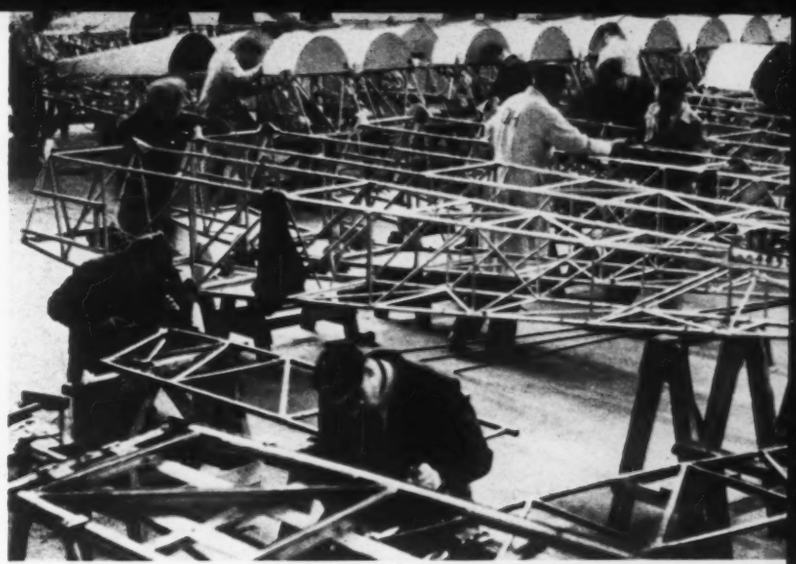

Fig. 1—Training plane fuselages are produced in large numbers by a Canadian plant utilizing oxyacetylene welding processes

Welding Is Adaptable to Design Changes*

By A. K. Seemann
Engineer
Linde Air Products Co.

ADAPTABILITY of welding to changing designs is well exemplified by its application to aircraft. This is normal and finds analogy in the growth and development of the automotive industry. There is this distinction, however, between the aircraft industry and the automotive industry. In the aircraft industry fundamental design changes develop so rapidly that there is no opportunity to set up a production line for even a matter of months. The best planes of today are obsolete tomorrow, and design changes take place even while the planes are being manufactured. As a result, despite the aircraft production figures published, the building of today's airplanes is largely a manual job with little opportunity to incorporate standard economical procedures such as are common in more completely developed industries.

Welded tubular steel design first made its appearance during the first World War, and more recently the stressed-skin monocoque fuselage of riveted aluminum alloy has come from the designer's board. Airplanes of tomorrow—of a size not now conceivable — may be large enough to justify the high strength-weight ratio of welded alloy steel in monocoque structures. At the present time important highly stressed and heavily shocked structural members of military and commercial aircraft are of welded construction. Examples of oxy-acetylene welded fuselage parts are shown in *Figs.* 1 and 2.

Army and Navy authorities and Civil Aeronautics Board, singly or in combination, have formulated specifications regarding designs and materials. It may be expected that these designs will be improved and refined as new knowledge is developed. However, it is not to be supposed that any two pieces of metal may be joined by welding regardless of their shape, size, or position. It is easy to label a drawing "weld here" but often it is difficult to fabricate the original design. Well-organized plants always consult the welding shop concerning new designs in an effort to make changes compatible with welded fabrication. In common with other methods of joinery the design must include an understanding of the joining process.

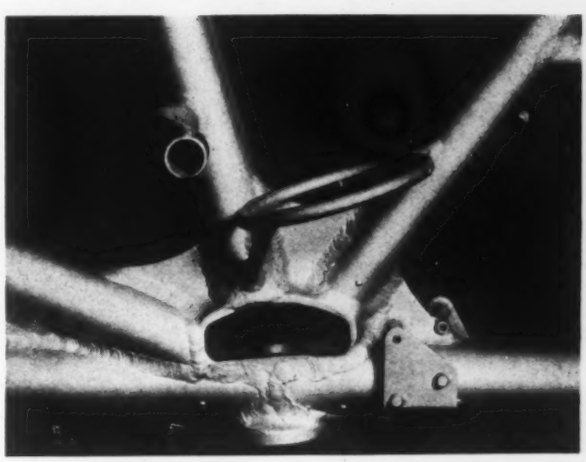

Fig. 2—Control fitting welded in joint affords an example of flexibility in airplane design

In aircraft construction the most common steel is SAE X4130. It was selected because of its high physical properties and the fact that it is available in desired shapes and can be fabricated with little

* Presented at the Twenty-second Annual Meeting of the American Welding Society, Philadelphia, Pa., October 20-24, 1941.

difficulty. SAE X4130 is an air-hardening steel which is hot-short, a property which must be taken into consideration if cracking difficulties are to be avoided during the welding operation. Many empirical expedients have been and are being used in aircraft plants but it is believed that a knowledge of the causes of cracking will enable the engineering departments to take the necessary cor-

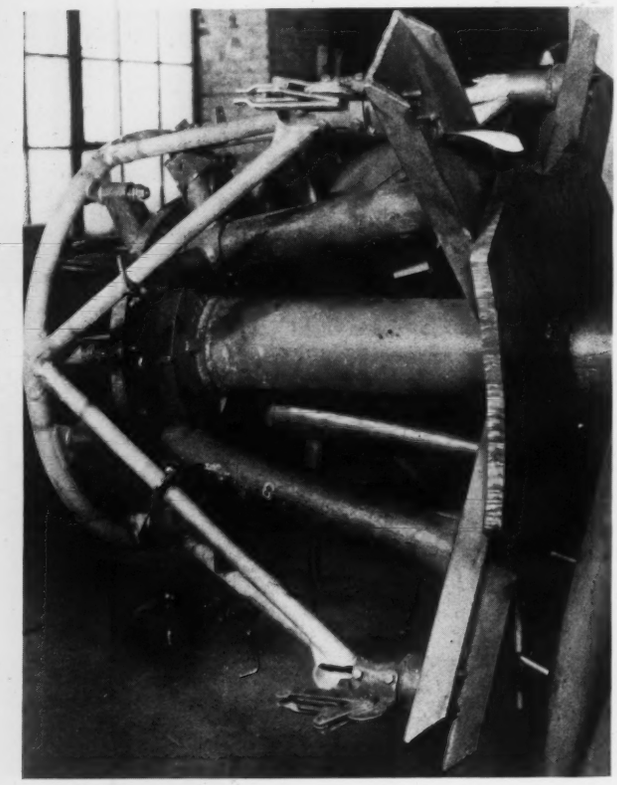

Fig. 3—Complete engine mount assembly may be rotated to expedite welding of highly stressed joints

rective measures to insure sound strong joints.

Cracking results from the liberation of tensile stresses. No cracking will occur if these stresses are absent or so slight they do not exceed the strength of the metal at any time during welding. In welding, steel is first heated to the fusion temperature. While the cooling, solidifying metal is at a white heat, it is devoid of ductility because, although the individual grains have solidified, they do not cohere.

Study of the forces which are encountered in welding provides a basis for the study of crack elimination. First, forces are developed through the expansion on heating and contraction on cooling. Second, there may be residual stresses in the metal parts themselves which are liberated by the welding flame. Third, stresses may be introduced in the welding operation. The majority of the "heat cracks" fall into the first group; that is, those developed by expansion on heating and contraction on cooling.

Usually cracks are located in the base metal at the edge of the weld. There are several reasons for this, the principal one being that the section is thinner than the weld and its shape changes more or less abruptly at this point. In the second place, the base metal, because of its nature, is usually more tender at a white heat than the weld metal. Third, the thin section at the starting point on the edge remains hotter a trifle longer than the thicker, reinforced section of the weld just inside the edge.

An obvious remedy for the edge-type crack has been recognized and adopted by some plants, namely, to begin the weld at some point on the seam and weld toward an outside edge rather than to start at an outside edge and weld inward along a seam. A slight compensating compression is thus brought to bear on the weld. Sometimes the forces operating on a weld compensate or neutralize one another, and since the net result is zero, the metal is not stretched or cracked. On the other hand, external conditions or a combination of circumstances may be such as to exaggerate the cracking tendency. The adjacent parts may be so rigid, either from their massiveness or be-

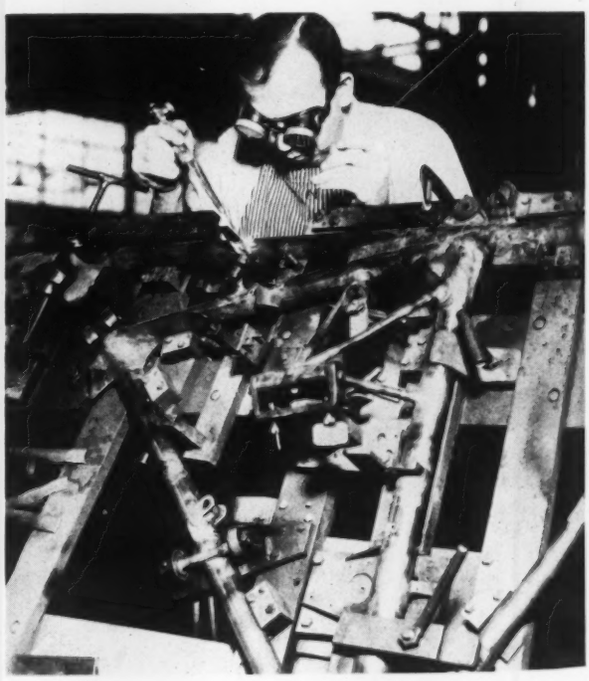

Fig. 4—Heavy welded tubular fuselage members are handled in a manner similar to the engine mount, Fig. 3

cause of being held immovable, that pure contraction occurs, resulting in a crack.

Conditions conducive to another type of cracking, known as interior cracking, can be overcome by a "double-welding" technique, which is particularly useful in joining thick material to thin material, such as a forging to a tube. Welding with this technique is performed in two steps. A deposit of weld metal is first made on both materials to be welded, as shown in *Fig.* 5, following the

outer limits of the proposed weld. The weld is then made, care being taken to terminate the weld within the original deposits of weld metal. In this manner an abrupt change of section is avoided, cooling takes place less rapidly, and residual stresses in the base metal are removed.

Mention has already been made of the tensile stresses created by contraction of metal on cooling. It may be convenient to compensate these forces mechanically or thermally. Jigs may be so designed that a slight compressive force is exerted during the welding operation. Obviously this force should not be of sufficient magnitude to cause upsetting. If the parts to be welded are so positioned that endwise movement is prevented, the local application of heat to the metal adjoining the weld area produces compressive forces sufficient to compensate for the contraction and thus avoids tensile stress on the part during cooling. This can be accomplished by local heating with the blowpipe, or, as practiced in a few plants, by enveloping the weld in an oxy-hydrogen flame. This expedient has the added advantage of insurance against oxidation, but has the obvious disadvantage of increasing welding costs.

Preheating Relieves Stresses

Local preheating also eliminates another cause of cracking. Tubing and sheet metal are not always stress-free prior to welding. This condition is brought about by such cold-working operations as straightening, bending, forming, and rolling. Residual stresses resulting from these operations are not usually uniformly distributed, and in localized areas may be sufficiently great to cause cracking if they are released during welding. Preheating these areas locally to a dull red will relieve the major residual stresses, and can be performed as a part of the welding operation.

There is a third cause of cracking which is relatively unimportant but which should be considered during examination of any cracked parts. If at the conclusion of the welding operation the part is stressed while hot, cracking may occur.

In review, there are three kinds of cracks: (1) those which originate from the heat of welding, (2) those which result from stresses which reside in the metal and are released by welding and, (3) those which are introduced after welding. Understanding of the principles underlying each enables the designer to specify means to prevent their occurrence.

For a number of years the requirements of strength, impact resistance, and ductility were satisfied by medium carbon steel, usually SAE 1025. As higher-strength steel was required, a careful search for a steel with the desired properties resulted in the selection of SAE X4130, a chrome-molybdenum steel containing about .30 carbon. This steel has been adopted almost universally and combines the desired physical properties with good machining and welding properties.

With aircraft becoming larger, faster and more heavily stressed, designers and engineers are searching for a steel superior to X4130. One that offers attractive possibilities is SAE X4340 which is a nickel-chrome-molybdenum steel containing about .40 carbon. This steel possesses desired physical properties and, as normalized, has a tensile strength in excess of 150,000 pounds per square inch. Preliminary experiments now undergoing confirmatory test indicate that this steel has good weldability, a necessary requirement for all good aircraft steels.

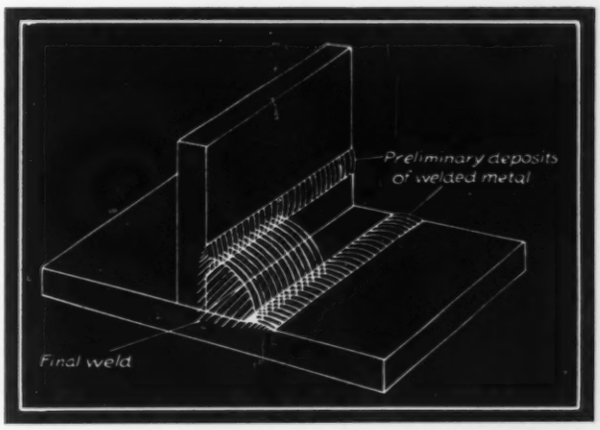

Fig. 5—To prevent cracks, provision should be made in the design of some joints to use the "double-welding" technique to avoid abrupt changes in section

Frequently the establishment of a procedure is left up to the welding foreman or a man who is considered a "good welder." When the welding has been completed, the welded part is visually examined, checked for measurement, and usually tested by the Magnaflux method. It is then assumed that the part is what the designer expected. However, in well-organized plants where good results are obtained consistently, a conference is held over each new design. Estimates are made of the amount of allowance needed for expansion and contraction, the direction of welding is decided upon, as well as the starting and stopping points. The various parts of the design are then prepared carefully to give a close fit, and the welds are made in accordance with this plan. If difficulties are encountered in the sample parts, the welding sequence is studied again and a new plan evolved. The parts are then subjected to appropriate testing in accordance with the types of stress for which the part has been designed.

With the design of suitable welding jigs, such as those shown in *Figs.* 3 and 4, the procedure for welding is marked on the blueprint. These markings include the starting and stopping points of all welds, the direction of welding and the welding technique. All operators are then required by the engineering department to follow this procedure exactly.

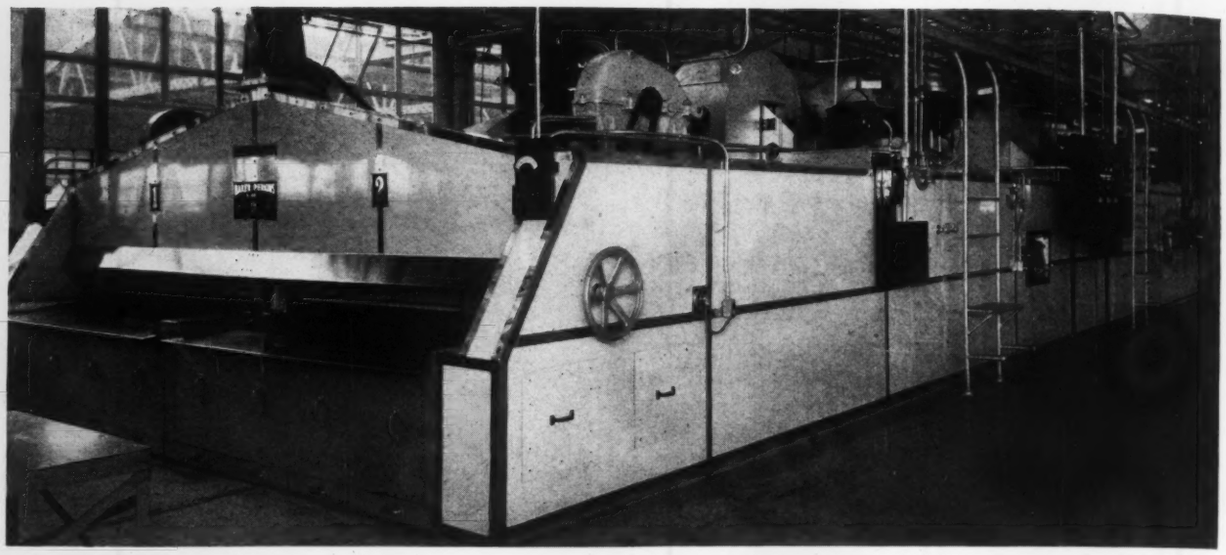

Fig. 1—Enameled exterior of baking oven is resistant to high temperatures and presents an hygienic surface

When To Utilize Porcelain Enamel

Part II—Sheet Metal Parts

By Emerson P. Poste
Consulting Engineer

SELECTION of correct stock is the first requirement for sheet metal enameling of parts such as utilized in the units shown in *Figs.* 1, 2 and 3. It is necessary therefore that the designer should be familiar with the basic principles involved. One authority has outlined the requirements thus: The sheet metal base for the majority of porcelain enameled machines should be:

1. Commercially pure iron or steel
2. Free from solid and gaseous impurities which might cause blisters and other surface defects
3. Distorted a minimum at enameling furnace temperatures
4. Easily welded, either by oxy-acetylene or electric process
5. Free from laminations, slag enclosures, or gas pockets
6. Suitable for drawing operations for stamped or spun ware
7. A proper surface for enameling.

The reference to "commercially pure iron or steel" involves two general types of sheet metal in common use. One is ingot iron and the other specially refined low carbon steel, both products of the openhearth furnace. Typical analyses are shown in TABLE I.

In developing enameling stock, the effect of high carbon content is the first controlling point to be recognized. Carbon blistering is characteristic of steels containing .2 per cent or more carbon. Early specifications often called for less than .15 per cent. Adverse effect of solid and gaseous impurities is a subject beyond the scope of this paper, and the same may be said with reference to point 5 in the listed requirements. Today, however, trouble due to base metal is unusual and, if present at all, arises from some incidental condition rather than through improper materials.

Heavy Gage Metals Are Best

Possible deformation of the stock under the heat of the enameling furnace is a problem that may need special consideration in any given case. This is important for parts having large, flat areas. A test† for determining the warpage characteristics of sheet metal is useful for applications of this type.

GAGE OF METAL: Selection of the proper gage of metal is of primary importance if defects such as warpage, sagging, hairlining, chipping, etc., are to be avoided. Too much emphasis cannot be placed on this phase of design.

Selection of thin sheets in an attempt to reduce cost may, instead, result in excessive loss and high cost. It is therefore better to err on the side of too heavy a metal. TABLE II may be used as a guide for the design of parts of medium size, finished in white or light colors, where only moderate rigidity and flatness are required. In the use of this table

†"Test for Sagging of Iron and Steel Sheets for Porcelain Enameling," Porcelain Enamel Institute; October, 1940.

the designer who errs on the side of using too heavy a gage will be on safer ground as previously stated. Parts requiring the use of deep drawing stock, but still largely flat in appearance, are usually more subject to warpage than if the design utilizes ordinary enameling sheets. This may be due, in some measure, to strain imparted by the forming operations which necessitated the use of the deep drawing metal, and to some extent to the inherent tendency of these stocks to warp easily. In such cases, recourse to heavier gages is usually an aid in overcoming the difficulty.

Should Be Reinforced With Flanges

DESIGN OF UNIT PARTS: Fabrication usually involves forming by bending, pressing, or drawing and may necessitate welding, either gas or electric.

TABLE I

Sheet Metals Suitable for Enameling

Element	Ingot Iron (Per Cent)	Low Carbon Steel (Per Cent)
Carbon	.015	.06
Manganese	.035	.32
Phosphorus	.005	.008
Sulphus	.025	.027
Silicon	Trace	.003
Copper	....	.07

The design of such parts must incorporate the basic principles developed in Part I[§] of this series if good results are to follow. With rare exceptions, all enameled parts should be reinforced by flanges, embossing or the equivalent. If enameling is to be in white or light colors, the radii of the flanges should never be less than 3/16 of an inch. When flanging is formed on a press or brake, it is good practice to weld the corners where the flanges meet. This reinforces the entire piece and prevents "working" or movement of the metal.

At best there will be required proper clearances between enameled parts. Allowances must be made for variations in thickness of stock and enamel as well as for the slight distortion caused by firing. Clearance for the enamel itself should be about 1/16-inch for each part. Still greater clearance must be provided in the case of parts fitting into a corner where the ground-coat enamel accumulates during draining. In such cases ⅛-inch clearance should be allowed. Similar provisions must be made for excess metal on the inside of welded corners, as the welding metal increases the thickness back of the weld. Where embosses or offsets are used to overcome warpage or for decoration, care must be exercised to insure that they are symmetrical with the piece. Spacers of some resilient material are recommended to prevent enamel surfaces being drawn tightly together during assembly. Such spacers should be of uniform thickness to reduce the possibility of producing uneven strains.

Flanges used to maintain the shape of a part should never be less than ⅜-inch deep and, if punched with holes for mounting, ½-inch is a more desirable minimum. In flanges of this depth, cutouts, notches, and holes larger than 5/16-inch should be avoided if possible. They weaken the flange and concentrate strains. Where flange notches or cutouts cannot be avoided, the corners should conform to a ¼-inch or larger radius and the die used in making the cut should be given sufficient clearance to permit the metal to be pushed toward the inside of the flange along the edge of the notch or cutout. This "extruding" or "burring" of the notch edge, together with the radius corners, will strengthen the flange and minimize to some extent the weakness inherent in such designs.

Where a large flange, one inch or more in width is visible in the final assembly, it is usually essential that it be kept straight and at the exact angle. This is difficult to attain unless the flange is properly supported during the enameling operation. The safest design is to have a side flange of equal depth meeting the exposed flange, or at least in the ratio of side flange to exposed flange of .33. Sometimes this is impossible due to some feature of design. As an alternative, although not desirable, a light gage angle may be spot-welded to both flanges as a reinforcement. In no case should this angle be welded to the back of the surface to be finished.

Another consideration in the design of relatively large flat pieces is the possible presence of loose met-

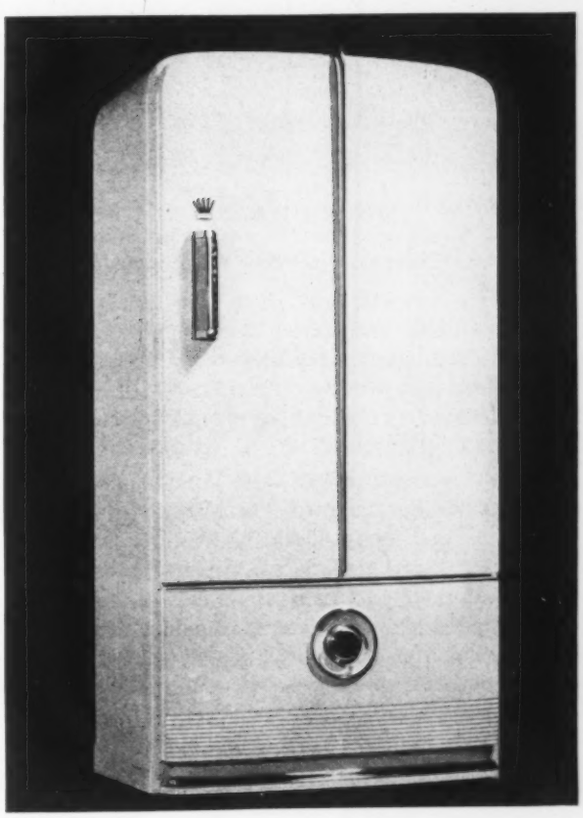

Fig. 2—Raised chromium trim adds to the dignity of refrigerator and at the same time increases protection of the enameled panels

§Machine Design, October 1941.

al at the center. Improper design or fabricating methods may result in an "oil can" effect that will cause warpage and strains on firing. This rim-bound metal can be reduced to a minimum by proper use of brakes and flanging presses, but in extreme cases the center metal may have to be taken up by embossing the edges of the piece.

Finish enamel of normal thickness cannot be carried to the edge of the base metal and yet present a satisfactory appearance. This limitation is met in a pleasing manner by the use of black edging. A coat of glossing black is applied and fired with the ground coat on the areas involved and subsequent cover coats are brushed off this black coating before firing. An alternate method that may be used for holes where a black area would be objectionable is countersinking the hole to a 3/16-inch radius.

If brushing is to be used on flanges of parts that are fitted into openings, it should go to the center of the radius. Large holes or cutouts for accessories should be brushed at least 1/16-inch beyond the accessory. Where needed for the protection of the edges of large parts, brushings should be at least ⅛-inch deep and wider at the corners. If brushing is not permissible, the flanges should be brushed to the center of the radius.

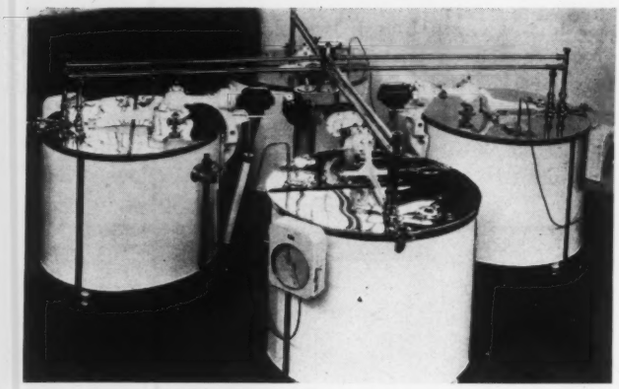

Fig. 3—Typical application of porcelain enamel to dairy equipment. Appearance and cleanliness factors are important to this type of equipment

Where it is necessary to weld lugs or clips to the back of parts for mounting to avoid visible bolts, etc., the welded parts should be at least two gages lighter and where possible cut out to reduce the total area of double thickness. Holes for mounting should never be located close to an emboss or flange. Holding clips and lugs should not be welded close to an edge bead or an emboss.

Sufficient allowance for accumulation of enamel in these attachment devices should be made to avoid strains from drilling, filing and other operations incident to assembling the product. The height and dimensions of clips to be tapped for screws should be such as to avoid danger of a tap damaging the part. The vertical sides of such clips or brackets should be weakened by cutouts to permit bending in assembly without distorting the flat surface to which they are attached. Long strips of any gage should never be welded to the back of parts for any reason.

The basic design determines whether or not a subframe is necessary. If a part is built up from individual pieces or panels, it is probably wise not to depend on their assembly as a supporting framework, especially in the gages ordinarily used for such work. In some instances, if the unit is small and of light weight, such practice might prove successful but is no criterion of what may be expected in larger and heavier units.

Welded Unit May Obviate Subframe

Recent advances in enameling practice have led to the development of structural unit designs wherein the exterior is rigidly welded and enameled as a whole. This method provides sufficient strength to permit the use of the enameled exterior as a body structure, obviating the necessity of a subframe. Such design, however, should not be undertaken without a thorough knowledge of all the factors of strength, rigidity and expansion, involved in the enameling of a structure of this type.

CHOICE OF ENAMEL: Designers should consider the selection of an enamel for a given use from two points of view—appearance and durability. While a beautiful gloss is characteristic of porcelain enamel, in special cases matte finishes are available. In general, glossy surfaces promote durability, particularly chemical resistance. With certain exceptions, colored enamels are not as resistant chemically as the white ones. Another consideration is the fact that chemical resistance is generally obtained at the expense of other qualities. Higher burning temperatures are involved, with more danger of warpage and other processing defects. The final enamel is less elastic and more subject to mechanical failure. Thus it is evident that, in the choice of an enamel, specifications for chemical resistance should not be overstated because other qualities necessarily would suffer.

Of the three types of enamel listed in Part I,[5] only the first two are used on sheet metal parts that would come within the scope of this presentation. Due consideration should be given to the requirements ranging from resistance to "normal atmos-

TABLE II

Maximum Areas for Moderate Rigdity

Gage of Metal	Total Square Feet for Various Widths 6-inch (sq. ft.)	12-inch (sq. ft.)	18-inch (sq. ft.)	24-inch (sq. ft.)
24	½	3*	5*	
22	1	3½	6*	8*
20	1½	5	8*	10*-15*

*Should be embossed, flanged or otherwise suitably reinforced. All parts larger than indicated should be made from 18 gage or heavier metal.

pheric conditions or solutions essentially free from acids" to resistance to "the organic acids such as acetic and citric." Obviously, enamels that meet the latter requirements would serve the former but at the sacrifice of certain qualities and usually at a higher cost. The third type of enamel "resistant to the mineral acids in general, with the exception of hydrofluoric" is usually furnished by firms specializing in this type of enamel applied to heavier stock than otherwise used in the industry.

Enamels with which foods come in contact are subject to special specifications. The two per cent boiling citric acid test mentioned in Part I[5] is often used in judging enamels for this use. The maximum allowable amounts of certain materials taken into solution on seven hours boiling are, according to one reference:

Total solids—.025 *g* per square inch wetted surface
Lead—.35 *mg* per 10 square inch wetted surface
Antimony—1 *mg* per 10 square inch wetted surface
Fluorine—1 *mg* per 10 square inch wetted surface.

Lead compounds are not used in making enamels of this type and this element would be present only through impurities in other raw materials.

TABLE III

Reflectance and Maximum Deflection

Coating Thickness (Inches)	Maximum Deflection (Inches)	Reflectance	
		Opaque (Per Cent)	Super-Opaque (Per Cent)
.005	.56	60	68
.010	.44	73	78
.015	.36	78	82
.020	.30	81	84

PROCESSING OF ENAMEL: In general, the ground coat is applied to sheet metal parts by dipping and removing the excess by draining or whirling, usually the former. While no definite rules can be laid down, parts should be so designed that the enamel will drain freely and uniformly over the surfaces that are to show in the final assembly and so that during draining the piece can be supported at points at which resulting defects in the enamel will not be objectionable. Cover coats are usually applied by spraying, occasionally by dipping. When sprayed, enamel is applied only to the surfaces that are to show. Such areas must be accessible to the spray gun. Recesses in which the sprayed enamel would accumulate should be avoided.

Processing Should Protect Against Sagging

The burning of the enamel involves temperatures at which sheet metal will sag of its own weight if not adequately supported. There are two general methods of accomplishing this, depending on the type of furnace involved. In the intermittent or box furnace, the parts are usually placed in a flat position on racks or "points" and the entire charge run into the furnace. With the continuous furnace, the parts are hung vertically on suitable "suspenders" which carry them through the furnace by an overhead chain or conveyor. The type of furnace to be used may, therefore, have a bearing on the design of the piece from the point of view of the method of supporting in the furnace. In either case, the design should avoid heavy parts that cannot be supported properly on the rack or that will not center under the hooks of the conveying system. There also should be freedom from uneven thicknesses of metal or reverse flanges and other features that will cause excessive shading from the source of heat, all of which tend to cause uneven heating and resulting complications.

ASSEMBLING OF PARTS: If the parts have been properly designed and processed, they should fit correctly on assembling. It should not be necessary to force holes for register. Enamel may require reaming from some holes, but no actual deflection of the metal should be necessary, with the exception of such attachment devices as may have been designed to bend slightly if required. It must be realized that enamel cannot be expected to follow appreciable local deflection of metal without mechanical failure.

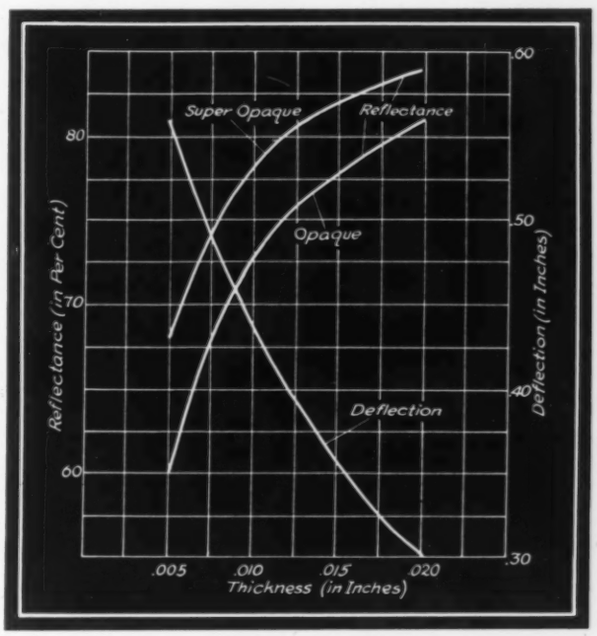

Fig. 4—Reflectance and maximum deflection curves for various thicknesses of enamel coatings

Chief causes of failure during assembly, or from assembly strains, are warpage and excessive enamel thickness. The former may result from faulty design, improper choice of enameling stock, or defects in processing. The latter may come from designs that promote local accumulation of enamel, improper enamel application, or too much "reworking" in an effort to salvage a part that has developed local defects.

THICKNESS OF ENAMEL: The thinner the enamel coat, the less is the danger of chipping. The con-

(*Continued on Page* 126)

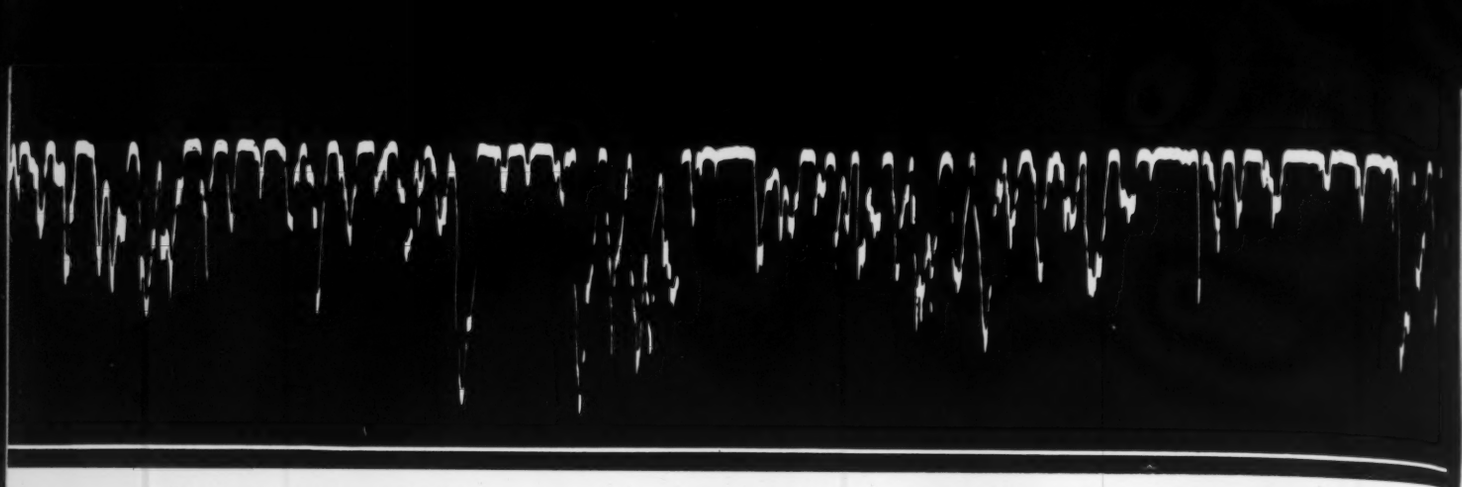

Fig. 1—Two passes of hone over a rough-bored surface results in appreciable smoothing as shown by profilogram

Honing Meets Designer's Need for Mass Production Precision

By L. S. Martz
Micromatic Hone Corp.

HONING, used chiefly to generate finished surfaces in bores and on some cylindrical parts in high production, combines several results in one process. An understanding of these and of the underlying principles is helpful in the design and specification of operating parts. Results obtained with honing are:

1. Correction of errors resulting from previous processing operations, and the generation of final geometric and dimensional accuracy within extremely close tolerance, ranging from fifty millionths to not more than one-thousandth of an inch, for diametric roundness and diametric and axial straightness
2. Generation of final dimensional accuracy coincident with the above geometric accuracy, within conventional tolerances ranging from .0005 to .002-inch
3. Generation of any desired type of surface finish and any degree of accuracy, all with maximum surface quality as may be specified for operating conditions involving parts design, loading, speed, lubrication, etc.
4. Control in one process of rapid and economical stock removal consistent with accomplishment of the foregoing results, under conventional high production conditions. This comprises stock removal ranging from .0001 to .040 or .050-inch on diameter, in bores ranging from ¼-inch diameter by ¼-inch long, to 20 or 30-inch diameter by 75 feet long—and at rates varying upwards to about 65 cubic inches per hour.

Factual study of surface generation and quality originated about ten years ago with the development of the profilograph at the University of Michigan. Measurement and analysis of thousands of profilograms of various types of surfaces, produced by various kinds of cutting tools, on various kinds of materials, has revealed the existence of the qualitative, as well as the quantitative, character of surface roughness. A definite relationship between the character of surface roughness and the method used in producing such roughness was also revealed. In machining process and frictional wear, this relationship is based solely and obviously upon the fundamental principles of mechanical work required in final processing, and the final surface generated by stock removal, plastic deformation or both.

When a piece of metal is processed by some type of treatment which fashions it into a desired form and size, it must be deformed—as by compression or tension, or stock must be removed from it as in shear. This deformation or stock removal is accomplished by machines or tools "which serve to transmit and modify force and motion."

Plastic deformation, as accomplished by com-

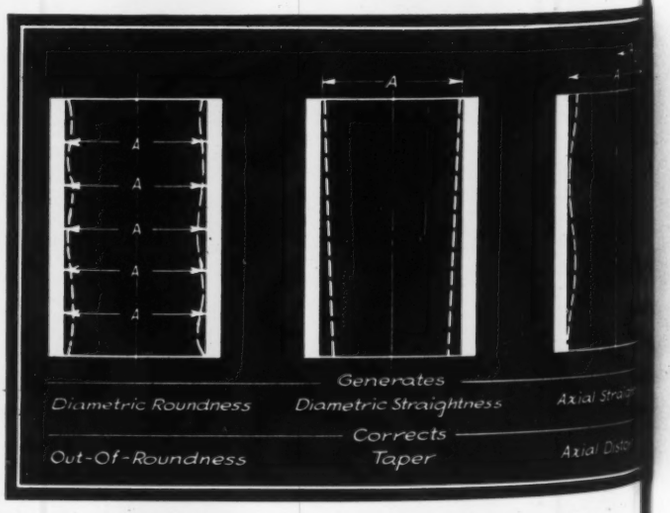

Fig. 2—Possibilities and limitations of honing are illustrated graphically by these three bores

pression in rolling or burnishing, and by tension in drawing operations, not only deforms the shape of a part, but also deforms its metallurgical structure —usually in the presence of severe frictional heat and stress. Stock removal by shear is produced only by stressing material beyond its rupture, or fracture point. In doing this work, some adjacent material is usually stressed beyond its yield point, forming a region of structural deformation which impairs the efficiency of the boundary surface. Successive machining operations, while removing all or part of this deformed material, may generate new regions of similar deformations, dependent upon the manner of force application.

Final surface finish and surface quality is generated on a majority of parts produced in the metal working industry by some form of abrading process. These abrading processes use either loose, or bonded abrasive under various applications of impact or impulse force and motions. Every abrading method differs from every other form of shear-cutting method of metal processing because of inherent factors in the abrasive material and the manner in which it is used. Also each method differs from all others in the manner of force application, the allowable numbers of simultaneous cutting contacts conventionally employed, the direction of abrasive travel, the amount and uniformity of pressure or force application and the cutting fluids used.

Utilizes Low Unit Pressures

In honing, as in every other type of shearing application, pressure is required to secure and maintain a desired degree of penetration of the grits into the work. Also, motion is required to convert this pressure into a directional force.

Total normal pressure conventionally used in honing results in unit pressures which range from approximately 55 to 75 pounds per square inch in rough honing, and from 40 to 55 pounds per square inch in finish honing. These pressures, distributed over thousands of simultaneous cutting tip contacts, result in unit pressures per grit which range from .003 to .015 of an ounce in finish honing, and from .019 to .324 of an ounce in rough honing.

Shearing stress influence is thereby localized over a large number of minute area contacts in the work surface, and high unit stress is reduced by distributing shearing force application through a large number of cutter tips. This makes it possible to control the uniform removal of stock in any desired amount, at any desired rate, from surfaces of any degree of roughness. The profilogram, *Fig.* 1, represents a rough bored surface, over which a honing tool has been passed for only two strokes.

Direction of motion used in hone abrading is important. It serves to maintain a uniform rate of grit and bond fracture, a uniform number of cutting tip contacts, and to produce a variety of surface finish patterns.

Honing tools, therefore, are not designed to generate concentricity, nor parallelism of bore axes. On the other hand, these features do make it possible for a bore which is undersize, or which requires additional correctional processing to be rechucked and finished to specified tolerances as indicated in *Fig.* 2.

Correction of out-of-roundness and generation of roundness, is produced by the rotary motion of the hone, and the freedom of the tool to center itself with the neutral axis of the hone. Correction of taper, and generation of diametric straightness, is controlled by the reciprocation, or longitudinal traverse, of the tool, combined with positive expansion, and equalized pressure application throughout the length of the honing stones and their stroke.

Correction of axial distortion and generation of axial straightness is accomplished by the use of sufficiently long stones to overcome any axial deformity in the bore. Some lengths are established in relation to bore lengths, primarily to assure uniform abrading effort or coverage of the surface.

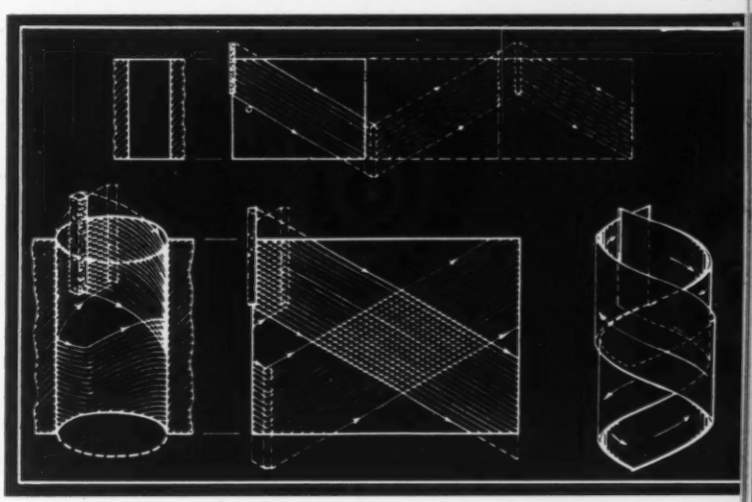

Fig. 3—Schematic diagrams of honing operations demonstrate the manner in which surfaces are generated

Simplest form of multi-directional abrasive actuation used in conventional honing applications is shown in *Fig.* 3. It combines simple rotational movement with simultaneous reciprocating strokes, or rapidly reversing traverse of the tool. This actuation generates a simple harmonic abrasive travel path. As here shown, for purposes of simplicity, the ratio is slightly more than two revolutions to one reciprocation.

Path of the stone travel if conceived as a thin metal shaving, would be as shown in the lower right hand corner of *Fig.* 3. The crossing of these paths on the forward and reverse strokes forms the symmetrical "crosshatch" surface finish pattern which is characteristic of this actuation.

Honing sticks are not allowed to return to their original starting position in the bore, but are actuated to successively overlap, or creep beyond, their previous positions at the end of each stroke.

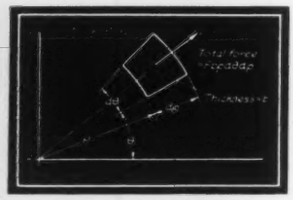

Fig. 99—Radial body force added to equilibrium system of elemental prism for rotating disk

Applying Theory of Elasticity

Part X—Rotating Disks

By R. E. Orton
Chief Engineer
Acme Steel Co., Chicago

CENTRIFUGAL forces developed by the rotation of disks frequently contribute to stresses of critical magnitude. In flywheels they usually afford the only stresses of importance and are the determining factor in design; whereas in such parts as grinding wheels they may well be the major item. In many other cases their contribution is sufficient to necessitate consideration. This discussion is limited to solid and hollow disks of rectangular sections. While shapes are not always of this form, usually it will be possible to secure, from this simple shape, an approximation sufficiently close for commercial design.

Because a particle in the disk is compelled to follow a circular path, a radial loading is produced and directed away from the center of rotation. In the previous discussions of this series the forces were applied to the surface of the body. Forces distributed throughout the mass of the object, as are these centrifugal forces or as are forces due to the weight or acceleration of the part, are termed "body" forces.

As outlined in the introduction to this series, the original development considered body forces as nonexistent. Therefore it will be necessary to return to basic equations and give consideration to the effect of introducing such forces. Since the stresses due to the weight of the disk generally will be small, this discussion will be limited to radial body forces, such as those produced by the centrifugal action of constant speed of rotation.

In *Fig.* 29* is shown the surface forces acting on an elemental prism in polar coordinates. *Fig.* 99 illustrates the radial body force which must be added to the previous system to represent the condition of an elemental particle in the rotating disk. If F is the force per unit volume, the total force on the particle becomes F times the volume of the particle. Adding this body force to the summation for the equilibrium equations gives the following to replace Equations 61 and 62

$$\rho \frac{\partial s_\rho}{\partial \rho} + \frac{\partial v_{\rho\theta}}{\partial \theta} + (S_\rho - S_\theta) + \rho F = 0$$

$$\frac{\partial S_\theta}{\partial \theta} + \rho \frac{\partial v_{\rho\theta}}{\partial \rho} + 2v_{\rho\theta} = 0$$

Since the loading is entirely radial it is apparent that the stresses in the rotating disk will have a ring distribution, similarly as in the radial surface loading of disks and hollow cylinders discussed in May issue. As was pointed out, the stress and strain components will not vary with change in angle. Therefore, the partial derivative of these components with respect to θ will be equal to zero. The equations of equilibrium for ring distribution become

$$\rho \frac{dS_\rho}{d\rho} + (S_\rho - S_\theta) + \rho F = 0 \quad \text{.....(164)}$$

$$\rho \frac{dv_{\rho\theta}}{d\rho} + 2v_{\rho\theta} = 0 \quad \text{.....(165)}$$

Solving Equation 165 gives for the shear stress

$$v_{\rho\theta} = -\frac{C}{\rho^2}$$

where C is the constant of integration. Since there is no surface load $v_{\rho\theta}$ must be equal to zero at any finite boundary, which can only be obtained making C equal to zero. Then

$$v_{\rho\theta} = 0 \quad \text{.....(166)}$$

a conclusion which may also be reached from the conditions of ring distribution. The principal directions are therefore radial and tangential, and S_ρ and S_θ give the principal stresses directly. The distribution of these stresses must be such as to satisfy Equation 164.

The condition of compatibility of the strain com-

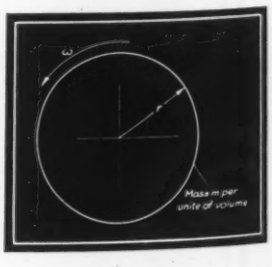

Fig. 100—Rotating solid disk. Stress is shown across radial section in Fig. 101

*MACHINE DESIGN, May 1941, page 55.

Elasticity in Practical Design

ponents now remains to be developed. In May issue, the unit strains in the radial and tangential directions are given as

$$\epsilon_\rho = \frac{\partial u_\rho}{\partial \rho}$$

$$\epsilon_\theta = \frac{u_\rho}{\rho} + \frac{1}{\rho}\frac{\partial u_\theta}{\partial \theta}$$

As previously mentioned, the strains will not vary with θ and therefore, for ring distribution

$$\epsilon_\rho = \frac{du_\rho}{d\rho}$$

$$\epsilon_\theta = \frac{u_\rho}{\rho}$$

Eliminating u_ρ between these equations gives

$$\epsilon_\theta - \epsilon_\rho + \rho\frac{d\epsilon_\theta}{d\rho} = 0 \quad \ldots\ldots (167)$$

Since $v_{\rho\theta} = 0$, $\gamma_{\rho\theta}$ also equals zero, and Equation

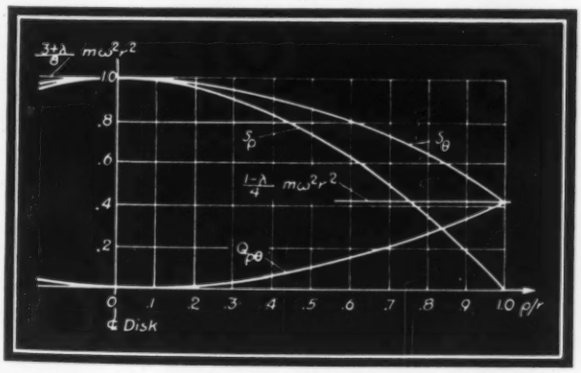

Fig. 101—Stress across radial section of a solid disk

167 is the "condition of compatibility" for ring distribution.

Equation 167 may be expressed in terms of the stress components by substituting for ϵ_ρ and ϵ_θ values for the condition of plane stress, as given in the May issue

$$\epsilon_\rho = \frac{(S_\rho - \lambda S_\theta)}{E}$$

$$\epsilon_\theta = \frac{(S_\theta - \lambda S_\rho)}{E}$$

from which the condition of compatibility in terms of the stress components is

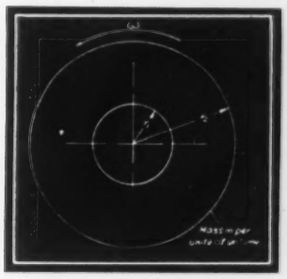

Fig. 102—Rotating hollow disk. Stresses are plotted across radial section in Fig. 104

$$(1+\lambda)(S_\theta - S_\rho) + \rho\frac{d}{d\rho}(S_\theta - \lambda S_\rho) = 0 \quad \ldots\ldots (168)$$

Stress distribution in the disk must now satisfy Equations 164, 168, and the boundary conditions. The solution of these equations is facilitated by the use of a stress function as a parameter. Any function, $\phi\ (\rho,\theta)$, will satisfy Equation 164 if it is related to the stresses by

$$S_\rho = \frac{1}{\rho}\phi \quad \ldots\ldots (169)$$

$$S_\theta = \frac{d\phi}{d\rho} + \rho F \quad \ldots\ldots (170)$$

as may be proved by substitution in Equation 164

Substituting Equations 169 and 170 in 168 and multiplying through by ρ gives the following for ϕ to satisfy

$$\rho^3\frac{d^3\phi}{d\rho^3} + \rho\frac{d\phi}{d\rho} - \phi + (2+\lambda)\rho^2 F + \rho^3\frac{dF}{d\rho} = 0 \quad \ldots (171)$$

Elementary mechanics gives the centrifugal force acting on a particle of mass m, as $m\omega^2\rho$, where ω is the angular rate of rotation in radians per second and ρ is the distance from the axis of rotation. Since F is the force per unit volume, if m is the mass per unit volume,

$$F = m\omega^2\rho$$

Substituting F from the above in Equation 171 gives finally for the condition of compatibility

$$\rho^3\frac{d^3\phi}{d\rho^3} + \rho\frac{d\phi}{d\rho} - \phi = -(3+\lambda)m\omega^2\rho^3 \quad \ldots\ldots (172)$$

Equation 172 is a form of linear differential equation known as "Euler's equation." It may be converted to one with constant coefficients by the introduction of a new variable, z, such that

$$\rho = e^z$$

the substitution of which gives

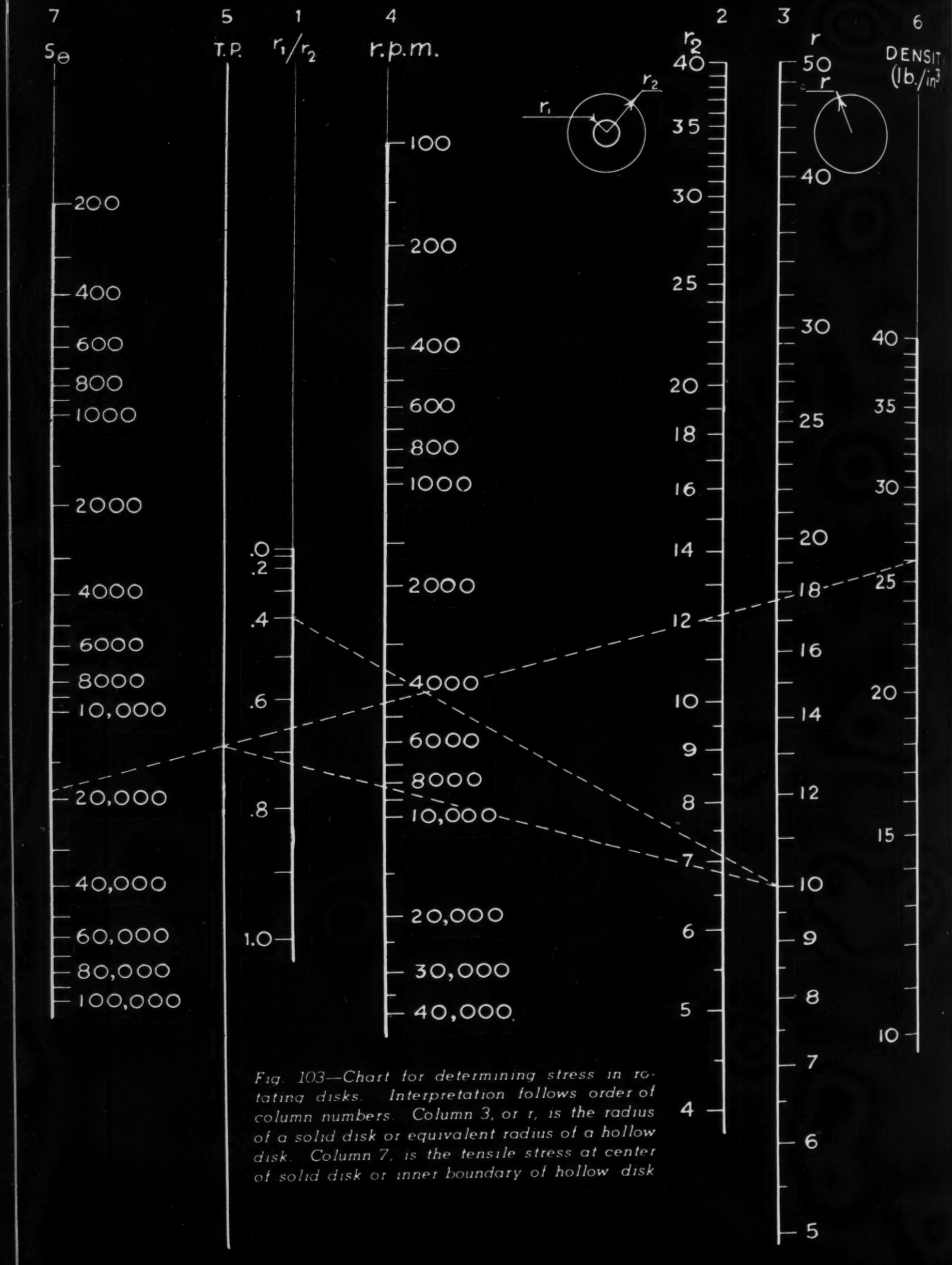

Fig. 103—Chart for determining stress in rotating disks. Interpretation follows order of column numbers. Column 3, or r, is the radius of a solid disk or equivalent radius of a hollow disk. Column 7, is the tensile stress at center of solid disk or inner boundary of hollow disk

$$\frac{d^2\phi}{dz^2} - \phi = -(3+\lambda)m\omega^2 e^{2z}$$

The general solution of this equation is

$$\phi = Ae^z + Be^{-z} - \frac{3+\lambda}{8} m\omega^2 e^{2z}$$

where A and B are the constants of integration.

Substituting for z in terms of ρ

$$\phi = A\rho + \frac{B}{\rho} - \frac{3+\lambda}{8} m\omega^2\rho^3 \quad \ldots\ldots\ldots\ldots\ldots (173)$$

which result may be checked by substituting directly into Equation 172.

Substituting ϕ as given by Equation 173 back into the stress relations of Equations 169 and 170,

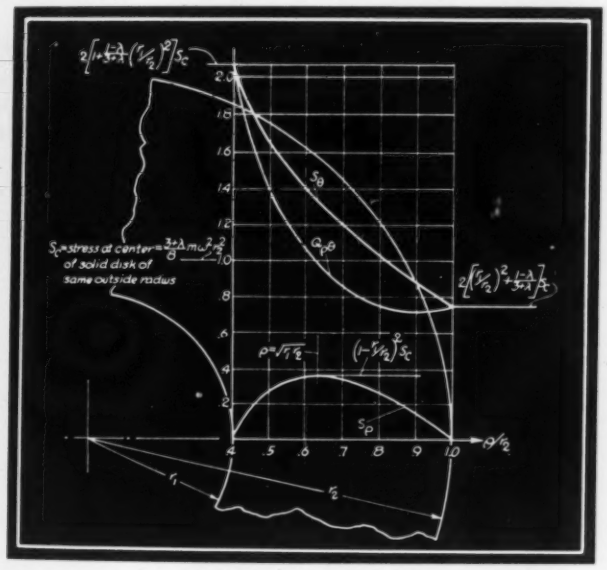

Fig. 104—Stress across radial section of a hollow rotating disk

and substituting for F, gives for the general equations of a rotating disk

$$S_\rho = A + \frac{B}{\rho^2} - \frac{3+\lambda}{8} m\omega^2\rho^2 \quad \ldots\ldots\ldots\ldots (174)$$

$$S_\theta = A - \frac{B}{\rho^2} - \frac{1+3\lambda}{8} m\omega^2\rho^2 \quad \ldots\ldots\ldots\ldots (175)$$

in which A and B are to be determined by the boundary conditions.

Since Equation 168 is predicated upon the assumption of plane stress only, Equations 174 and 175 will not hold for the case of plane strain. The sum of the principal stresses is

$$S_\rho + S_\theta = 2A - \frac{1+\lambda}{2} m\omega^2\rho^2$$

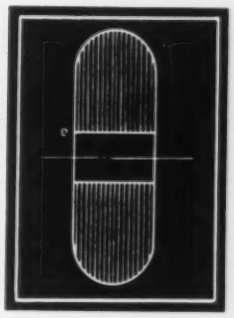

Fig. 105—Stress in irregular shape may be approximated by dividing into thin disks and analyzing each separately

Since the strain in the third direction is a function of $(S_\rho + S_\theta)$, see Equation 26 in the March issue, the strain will vary over the cross section and the stress distribution developed from Equations 174 and 175 will hold only for relatively thin disks where assuming plane stress distribution is warranted. It should be noted that this is contrary to the condition under radial surface loads only where, as discussed in the May issue, plane stress exists regardless of the thickness (or length) of the "disk."

These equations will be applied first to the solid disk shown in *Fig.* 100. Subtracting Equation 175 from 174 gives for the stress difference

$$S_\rho - S_\theta = \frac{2B}{\rho^2} - \frac{1-\lambda}{4} m\omega^2\rho^2$$

At the center of the disk, from the symmetry, S_ρ must equal S_θ. Therefore $(S_\rho - S_\theta)$ and the second member of the right side of the preceding equation approach zero as ρ approaches zero, from which

$$2B \lim_{\rho \to 0} \left(\frac{1}{\rho^2}\right) = 0$$

which can only be satisfied by making B equal to zero.

At the bounary, $\rho = r$, there being no surface forces, S_ρ will be equal to zero, which gives for the constant A

$$A = \frac{3+\lambda}{8} m\omega^2 r^2$$

Substituting these values of the constants back into Equations 174 and 175 gives for the stresses in the solid disk of *Fig.* 100

$$S_\rho = \frac{3+\lambda}{8} m\omega^2(r^2 - \rho^2) \quad \ldots\ldots\ldots\ldots (176)$$

$$S_\theta = \frac{3+\lambda}{8} m\omega^2 \left[r^2 - \frac{1+3\lambda}{3+\lambda} \rho^2 \right] \quad \ldots\ldots\ldots (177)$$

and the principal stress difference, $Q_{\rho\theta}$

$$Q_{\rho\theta} = S_\theta - S_\rho = \frac{1-\lambda}{4} m\omega\rho^2 \quad \ldots\ldots\ldots\ldots (178)$$

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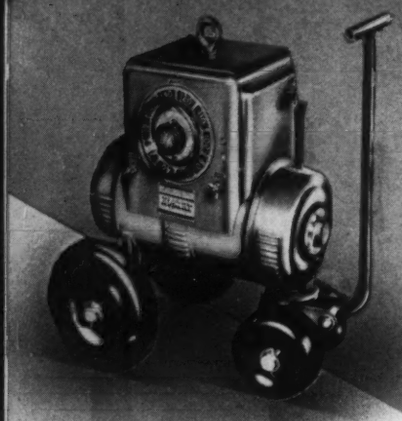
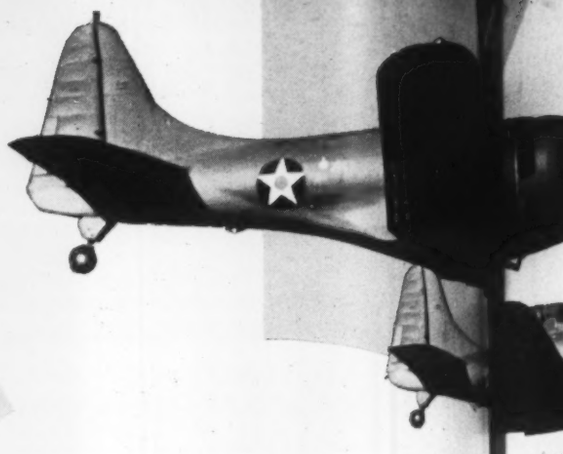


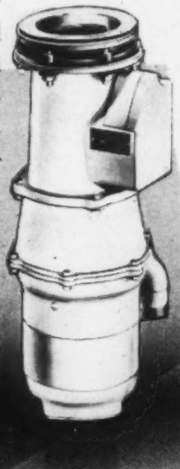
Left—Maintenance of a "soft arc" and an ability to "hang on" even under low current conditions is attributable to a design consisting of four laminated main poles and four interpoles in the Hobart arc welding machine. Especially designed for aircraft applications, welding X-4130 chrome-molybdenum steel and stainless steel in light to medium gages is facilitated. Obviating the necessity of returning to the machine, voltage and current are adjustable by dual remote control from the welding station



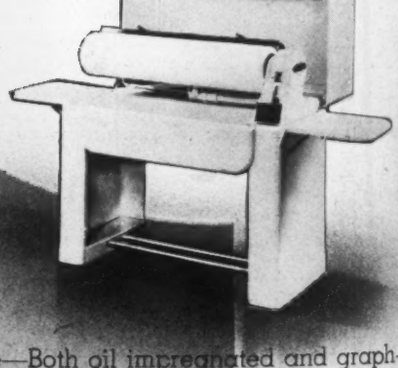
Design Features IN NEW MACHIN

(For new machine listing see page 144)

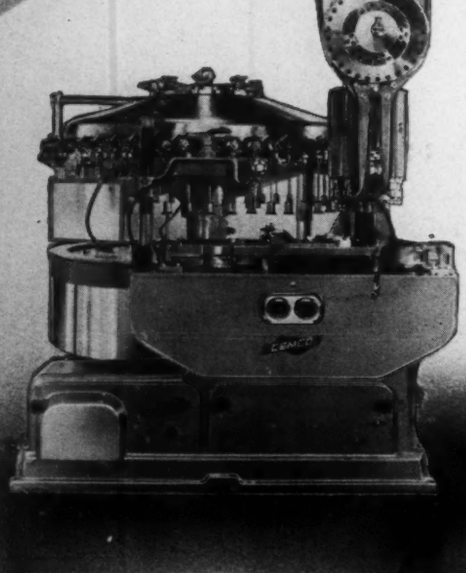
Right—Noise and vibration from grinding chamber of General Electric Disposall are isolated by neoprene gaskets. Twelve carboloy shredders are cast integrally in a special alloy sleeve. For maximum resistance to wear and abrasion the sleeve is through-hardened so that it is resistant even to cold-chisel blows. Permanently lubricated roller bearing is the only bearing used in the machine and supports motor flywheel and shredder assembly. Bearing is resiliently mounted for further isolation of vibration

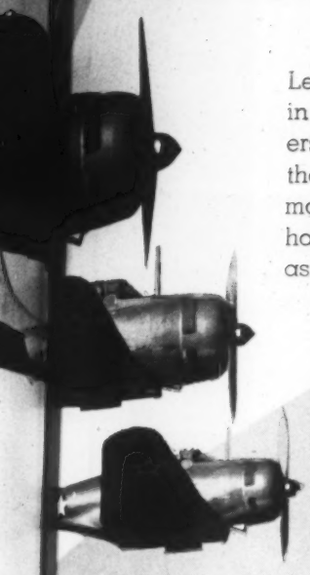


Below—In food machinery, particularly for handling carbonated beverages, corrosion resistance is of primary importance. This is achieved in Cu[illegible] bottling machine by use of stainless steel, nickel silver and parkerized iron and steel for all parts exposed to the product. Drive is by means of 2-horsepower motor through a worm gear and three spur gears. Further protection is afforded by automatic lubricating system which shuts off the machine if oil supply fails during operation



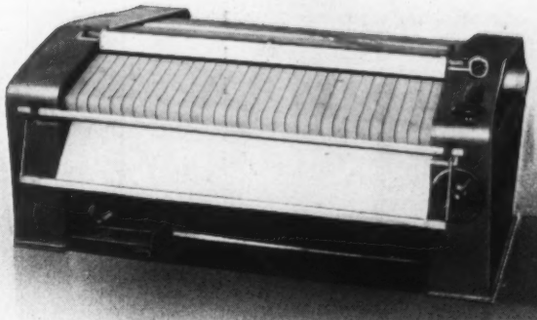
Above—Both oil impregnated and graphite impregnated sintered bronze bearings provide lifetime lubrication in Conlon ironers. Affording simulation of hand-ironing action, a shoe glides back and forth along the two-speed roll





Left—Designed on the basis of data obtained in actual combat service, Douglas dive bombers are typical of those being supplied to both the army and navy. Equipped with the most modern aviation developments, the planes have built-in self-sealing fuel tanks as well as provision for protective armor plate and offensive gun implacements

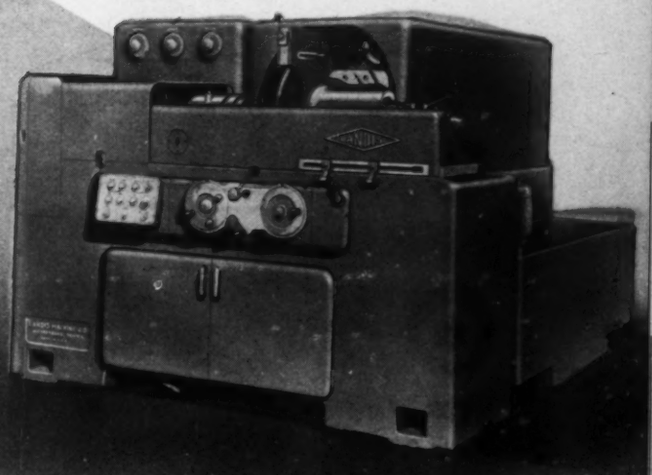
Above—Positive feed and automatic cycling of the work table is obtained with hydraulic control in Van Norman milling machine. Belt adjustment to main driving pulley is accomplished by mounting the three horsepower spindle transmission drive motor on a hinged plate. Cast integral with the upright column, heavy box-type ways afford support for the spindle head slide. Drive is transmitted to the spindle through a vertical shaft from the change speed transmission



Left—Use of a fluid heating medium possesses the advantages of better heat transfer at higher temperatures in Western commercial ironer. Drum temperatures of 450 degrees Fahr. are obtained by circulating the fluid between a built-in boiler and the ironing drum. Use of a water tube type boiler heated by induced draft from a motor-operated blower effects efficient combustion of the gas or oil

Below—Accurately scraped surfaces on the work table and wheel slide of Landis precision thread grinder maintain full bearing areas at all times. Overhanging of the machine base by the table is impossible. Positive and accurate table feed is obtained by a hardened and ground leadscrew mounted in antifriction bearings. Cooperating leadscrew nut is of alloy bronze for resistance to galling

Left—Being produced by Allis-Chalmers by mass production technique the new 90 millimeter anti-aircraft gun is the most powerful weapon of its type yet developed. Capable of being set up from its traveling position in less than six minutes, the gun can fire a projectile over 35,000 feet into the stratosphere and is adaptable to automatic control by fire control instruments



MACHINE

Editorial

DESIGN

Never Has Need for Invention Been More Acute!

INVENTION and research at no time play a greater part in the progress and welfare of a nation than during periods of war. Many instances occurred in the previous world conflict wherein inventions—a notable example of which was the tank—went far toward settling the issue. It may well be that the current strife will be brought toward a close by some heretofore unthought of, or seemingly impractical, device.

In some ways we are fortunate, particularly when one considers the inherent inventiveness of United States' scientists, engineers, technicians and even laymen, that in a national emergency an immediate increase occurs in the flow of suggestive ideas. Few of these reach maturity, yet the more there are the better are the chances of some really worthwhile inventions coming to light.

Indicative of the influx of inventions during crises is the fact that the National Inventions Council of the Department of Commerce has already received, classified and evaluated some 34,000 inventions and inventive ideas, even though the council has been established only about one year. Greatest in volume have been inventions of a military character, followed by those in the field of aeronautics. Many have been received also in the more general field of design as typified by machine tools, foundry machinery and other equipment allied with the defense effort.

As a clearing house for inventions and suggestions of value in national defense the council, headed by Dr. Charles F. Kettering, is filling an urgent need. Staffed by capable scientists and engineers, the council gives assurance of prompt and sympathetic evaluation of all ideas submitted.

Few men are better qualified than are designers—by reason of their developed faculties of initiative and analysis—to further the country's cause in the troublous days ahead by putting forth a supreme effort to submit to the Council ideas of practical value. May it later be said that the members of the design profession, singly and collectively, made one of the greatest contributions toward the return of peaceful, stable and prosperous times.

L. E. Jermy

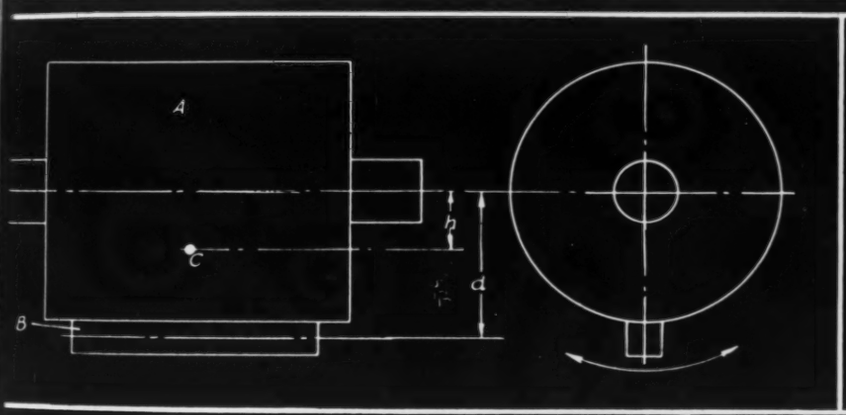
Determination of Flywheel Effect, WR^2

By Gene F. Rose

Copperweld Steel Co.

DETERMINATION of "flywheel effect" is essential in the design of many machines. Calculation of this rotational inertia or WR^2 from detail drawings is laborious unless the parts are fairly simple in shape. Hence, in most cases, the value is obtained by experiment.

Some of the methods[1] have been developed specifically for electrical machinery and



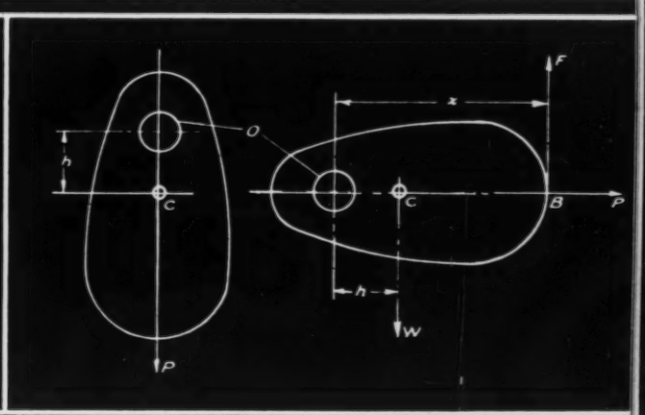


Fig. 1—Left—Set-up for determining WR^2. Fig. 2—Right—Method of locating center of gravity

make use of retardation curves and data on windage and other losses. In other methods,[2,3] the value is obtained from empirical data.

Advantages of requiring a minimum of auxiliary equipment and comparatively few physical measurements are possessed by the following method, equally applicable to balanced rotors and rotors in any state of unbalance.

If a statically balanced body, A, is supported on its axis and a known weight, B, is rigidly attached to it as shown in *Fig.* 1, the center of gravity, C, of the resulting system is below the point of support. The new system is therefore a pendulum which oscillates about the axis with a period T depending upon (1) rotational inertias of A and B (I and I'), (2) the weight, w, of B, and (3) the distance, d, from the axis to the center of weight B. The value of I may be determined by the single equation

$$I = .814\, wdT^2 - I' \text{ (lb.-ft.}^2\text{)} \qquad (1)$$

in which $I' = wd^2$ (assuming that the radius of gyration of the auxiliary weight equals its distance from the axis to its own center of gravity).

Hence the auxiliary weight should be approximately 5 pounds for every 100 pounds of weight of the body, A. If much less than this value, the period, T, will be so long that the friction effect of the axis support will be appreciable. If much greater, correction must be made for the rotational inertia of the auxiliary weight about its own axis. The previous expression for I' then becomes either

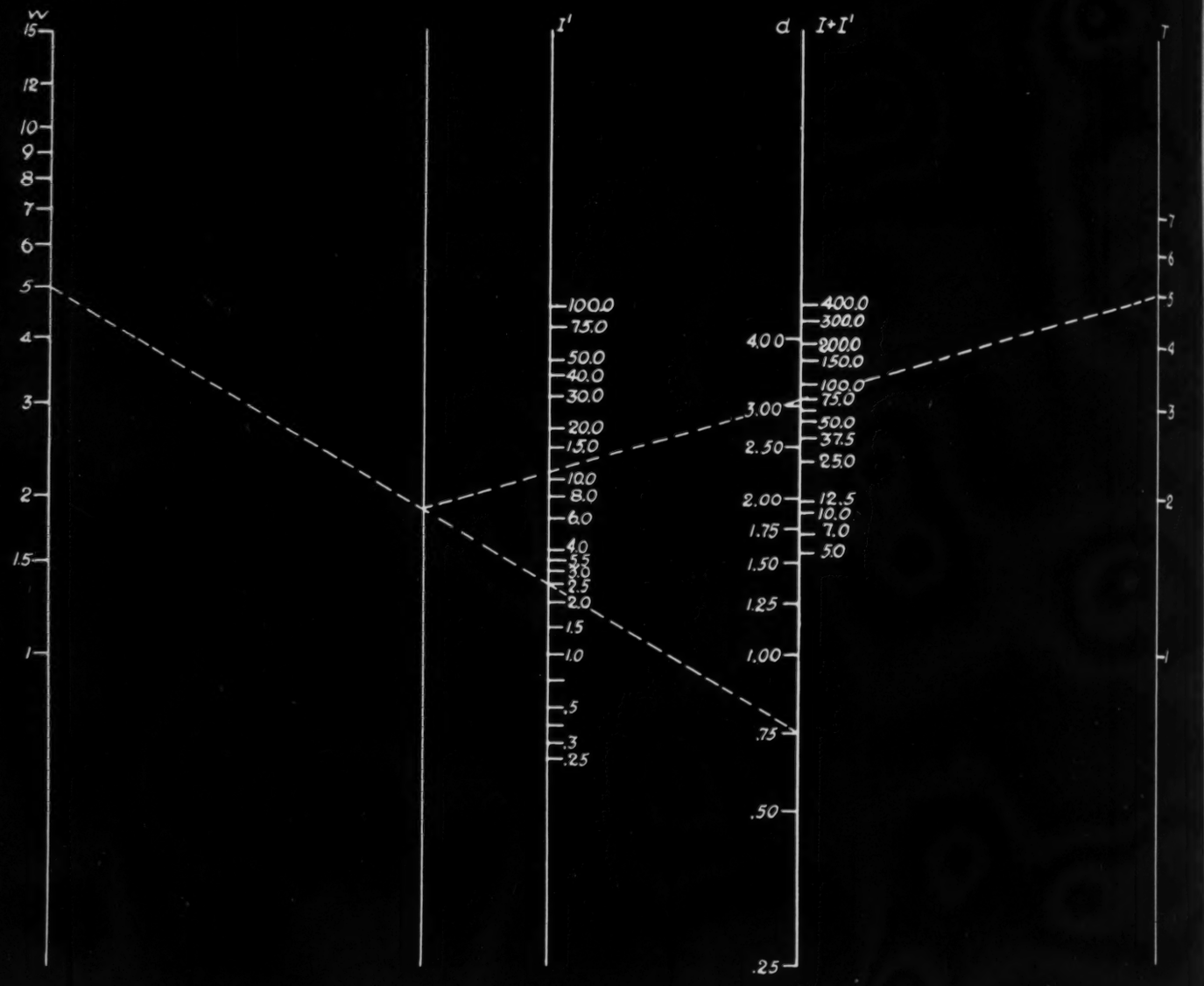
$$I' = wd^2 + \frac{1}{6}\, wab$$

or

[1] Preliminary report on a proposed test code for synchronous machines (American Institute of Electrical Engineers, New York City, January, 1937) §§84-88

[2] Ibid §83

[3] Edmunds, H. M. Friction Losses in Rotating Parts, Machine Design, August 1940 pp. 56-57



$$I' = wd^2 + \frac{1}{2}wc^2$$

the first of which is for a rectangular bar with sides a and b; the second for a circular bar of radius, c.

If a Sundstrand or similar balancing machine is used as the rotor support and if the weight of the rotor is small, a correction may be applied for the supporting wheels

$$4I_s = \left(\frac{r_o}{r_s}\right)^2$$

which should be subtracted from the value of I obtained by Equation 1. Then, I_s is the moment of inertia of each supporting wheel; r_o and r_s are, respectively, the radius of the shart and of the supporting wheel.

In measuring the time period, T, of oscillation of the pendulum, the system should not swing more than about 5 degrees so that the vertical displacement of the center of gravity is negligible. If the rotor to be measured is statica ly unbalanced, no auxiliary weight is required. The body is allowed to oscillate and its WR^2 is calculated

$$I = .814\,WhT^2 \text{ (lb.-ft.}^2\text{)} \quad \ldots\ldots (2)$$

where W is the weight of the body or rotor and h is the distance in feet from the shaft axis to the center of gravity.

The value of Wh in Equation 2 can be obtained as indicated in *Fig.* 2. The rotor is allowed to come to rest in its supports. A plumb line, OP, is dropped from O and an index line is drawn along it on the side of the rotor. The rotor is then rotated 90 degrees (line OP is then horizontal). A spring balance is attached at some convenient point, B, and the vertical force, F, is measured. Then $Fx = Wh$ is the required value.

The accompanying nomogram provides a solution of Equation 1 for balanced rotors. From the empirical data for w, d and I, I' and $I + I'$ may be obtained from which the desired I is derived by subtraction.

In the example, $w = 5$ lb., $d = .75$ ft. and $T = 5$ sec. Hence $I' = 2.5$ and $I + I' = 76.3$ lb-ft.^{2} and, by subtraction, $I = 73.8$ lb-ft.^{2}

ALLOYS

Timely information about metals... CATALOGUED for your convenience

Specific answers to many of your questions about the selection, fabrication and uses of Nickel alloys are available to you quickly from our files.

This fund of helpful information we have gathered, checked and condensed into convenient printed form. The graphs, charts and shop guides are especially useful to men handling new materials or performing unfamiliar operations . . . and to new employees. This literature is available on request.

You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. These engineers are offering timely suggestions to many vital industries during the present emergency.

Why not drop us a card asking for list of available literature. Your request for the assistance will receive prompt attention.

NICKEL

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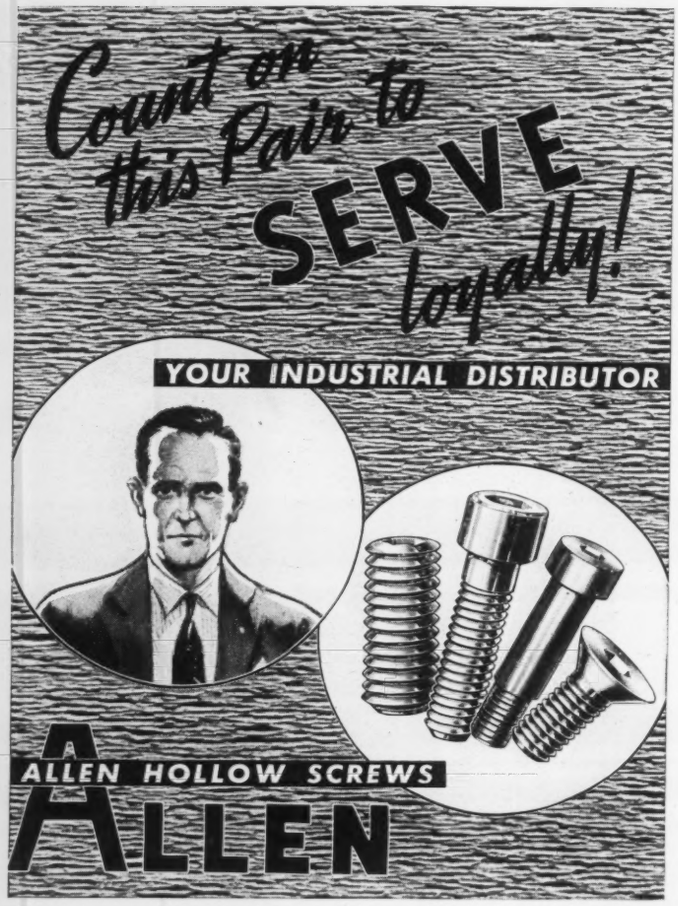

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Professional Viewpoints

" . . . keep complete file"

To the Editor:

Will you be kind enough to let us know if there has been published in your magazine during the past ten years any articles on the determination of the stresses in rayon spinning pots or similar objects rotating at very high speeds?

We have a complete file of "Machine Design" from January 1930 to the present with the unfortunate exception of June and July 1934 in which issues appeared the articles on the "Design of Helical Gears" by W. P. Schmitter. Would it be at all possible to obtain a copy of these articles for our files? Because of the frequent references made to these articles in current literature, we feel that they would be a valuable addition to our plant library.

In conclusion, we would like to express our appreciation of the series on "Applying Theory of Elasticity in Practical Design", by R. E. Orton. Will reprints be available at the conclusion of the series as they were for the previous articles by the same author, and if so, may we have a copy?

—S. A. BALKAN, *Research Department*
Saco-Lowell Shops

Decision regarding the reprinting of Mr. Orton's series will be made upon the completion of the series in the December issue.—Ed.

" . . . adds greatly to magazine"

To the Editor:

We want to congratulate you on the new cover for MACHINE DESIGN. It adds greatly to the magazine itself and we are sure the insides of MACHINE DESIGN will always be of the same high quality.

—A. T. HAPKE
Bell Aircraft Corporation

To the Editor:

Reactions of various individuals within our organization, along with mine, are, "Your new cover is a decided improvement over the old one and should add considerable prestige to the publication." I am confident you will find most readers of MACHINE DESIGN approve of this step you have just taken.

—H. L. MARTIN
Diamond Chain & Mfg. Co.

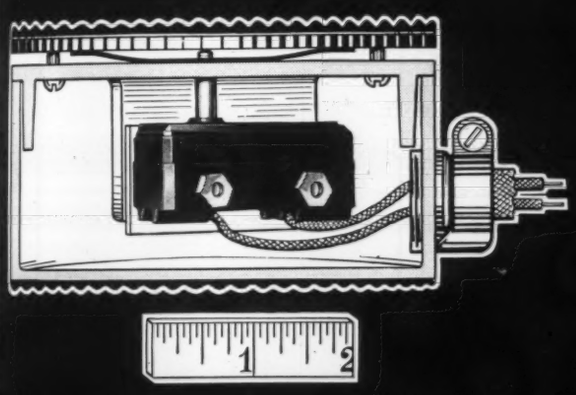
" . . . articles are comprehensible"

To the Editor:

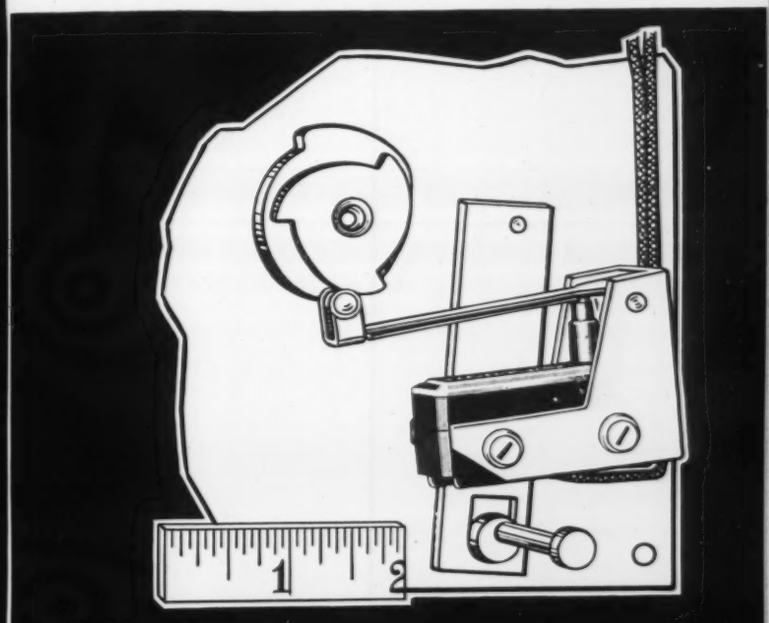
For the past several months you have published articles concerning "Applying Theory of Elasticity in Practical Design". Even though I have had

Only MICRO SWITCH Meets the Requirements of these two Manufacturers

Here are two specific examples of the sensitivity, precision, and absolute and unfailing dependability of the Micro Switch



The General Control Company, Cambridge, Mass., designed this Manual Control Switch for "millions of safe, sure operations." Controlled by foot, knee, hand or elbow, it is used for bench grinders, drill presses, spot welders, photographic equipment, X-rays, conveyors, alarms, dictating machines, etc. Contact mechanism consists of Micro Switches R-RS, G-RS or B-RS described on page .05, Section 1, Micro Switch Catalog No. 60.



C. A. Dunham Company's "RT" Control for large building heating systems has a YZ-RS Micro Switch which operates every 20 seconds, day in and day out, to open and close the main steam valve. The switch is operated by a lever which is cam actuated. Note that the switch is mounted on an arm that can be swung through a small arc to provide a timing adjustment. The Micro Switch is the heart of the system—for details see Catalog No. 60, page .05, Section 1.

Study the two illustrations above. Read about the functions which the Micro Switch performs in both cases. In one, the requirement is millions of safe, sure operations; in the other, dependable operation every twenty seconds day in and day out.

Requirements and records of performance such as these have made the Micro Switch the preferred choice of design engineers who are involved in the designing and development of products where precision switching actuated by pressures lower than an ounce and movements as low as 2/10,000ths of an inch are required.

These engineers find that the combination of small size, light weight, small pressure and movement differentials are more quickly and economically obtainable by the use of a Micro Switch than any method they themselves can devise. Furthermore, the wide range of engineering service which is available to them in problems involving precision switching enables them to reduce their own engineering expense.

The Micro Switch is listed by the Underwriters' Laboratories with ratings of 1200 V.A. loads from 125 to 600 Volts A.C.

Why not investigate the applicability of the Micro Switch to your product? If it involves an intricate application of precision switching, write us regarding the problem. We will submit suggestions.

Micro Switch Catalog No. 60 is a veritable handbook for engineers covering snap action switches, their characteristics, actuation, operation and application to any use of product. A copy will be sent on request.

Micro Switch is a trade name indicating manufacture by Micro Switch Corporation.

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little previous experience in studying or using the theory of elasticity, I find that the articles as presented are not only interesting but also comprehensible.

Our company library has MACHINE DESIGN on its shelf so that it is always available. However, I would like to have a compact set of notes to which I could refer more easily. Do you have any reprints available? If so, I would appreciate it very much if you would send me a set of these reprints.

—J. CHERRY, *Engineering Dept.*
Westinghouse Elec. & Mfg. Co.

" . . . valuable and well-treated"

To the Editor:

We note that you have published the serial articles entitled "Selecting Special Motors" in booklet form and have ordered three copies for our engineering departments. These articles are a valuable source of information and you have performed a fine service in making them available.

There is another series of articles on "Applying Theory of Elasticity in Practical Design", by R. E. Orton, which we are following closely. We are wondering whether you intend to put this in book form after the series is completed. This subject is so well treated that it would seem there should be a good demand for permanently bound copies.

—CHARLES H. RICHARDS
The Heald Machine Company

" . . . for personal file"

To the Editor:

The article "Designing Shafting for Static or Fatigue Loads" by Joseph Marin in the August issue of your publication is very good and I would like to have a copy of the article for my personal file. Will you please send to me a copy of the magazine containing the article? I shall be glad to remit any charges involved.

—D. ELLIOTT STEEL
Cleveland, Ohio

" . . . must cease and desist"

To the Editor:

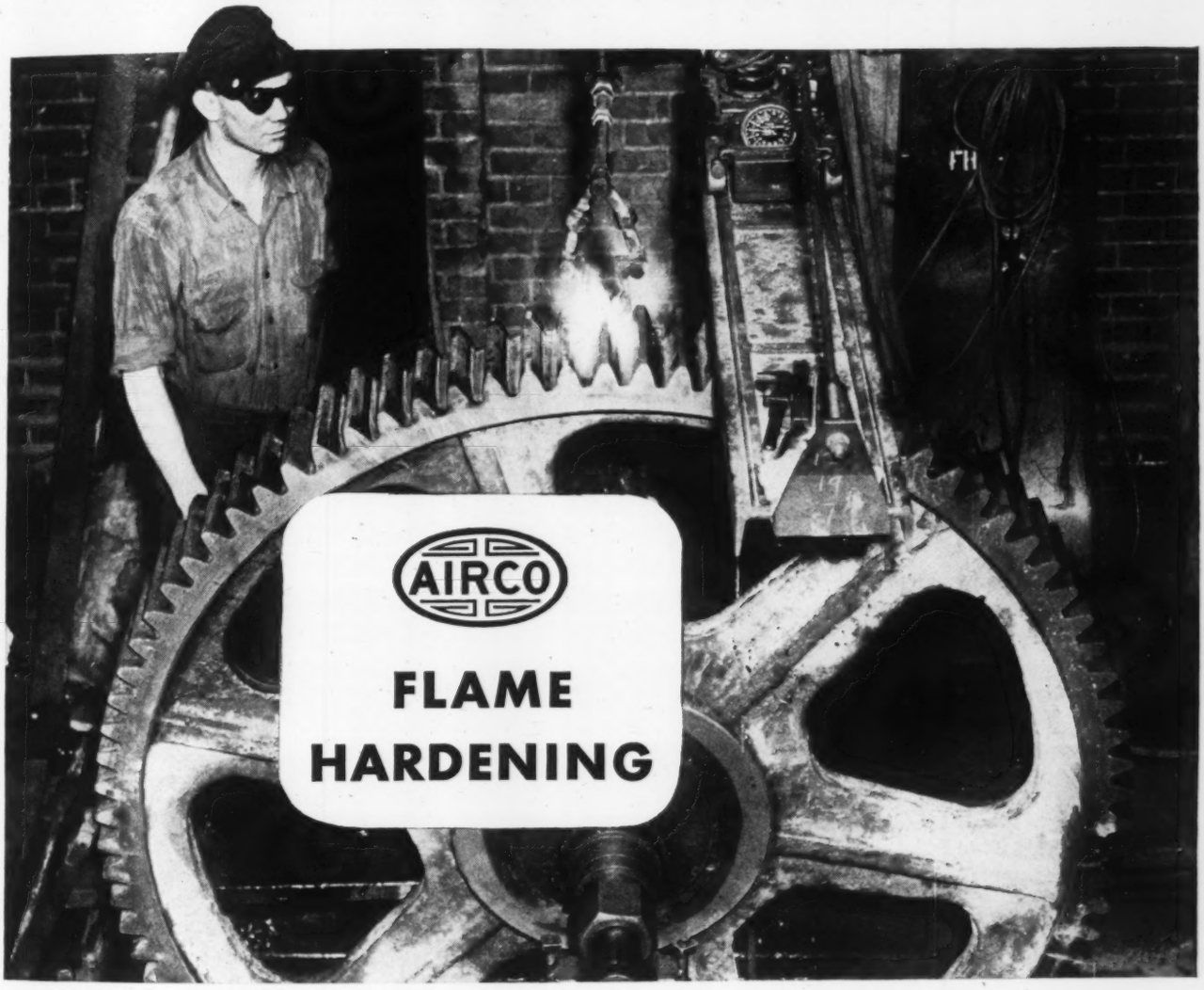
I have been following Orton's articles, "Applying Theory of Elasticity in Practical Design", in your magazine. I am much interested in this subject and am pleased with your method of presentation. However, I find that the library does not appreciate my tearing apart our magazines and have issued a "cease and desist order."

Because of this "restricting" policy, I am forced to ask you whether reprints are available and their price. If possible, I would like to obtain the whole series in one unit.

—OLIVER FRASER, JR., *Aeronautical Engineer*
Carnegie-Illinois Steel Corporation

MULTIPLY THE SERVICE LIFE

OF VITAL WEARING SURFACES WITH...



With replacement parts at a premium, it's more important than ever to get the longest possible service life out of vital wearing surfaces. That's why so many manufacturers are relying on the Airco Flame Hardening Process to do just that. For this proved process increases the life of wearing parts immeasurably by hardening the surface — yet the core retains its original toughness and shock-resistance. Sprockets, gear teeth, wearing surfaces, shafts and a multitude of shapes regardless of size, are quickly and economically hardened for longer life this modern Airco way.

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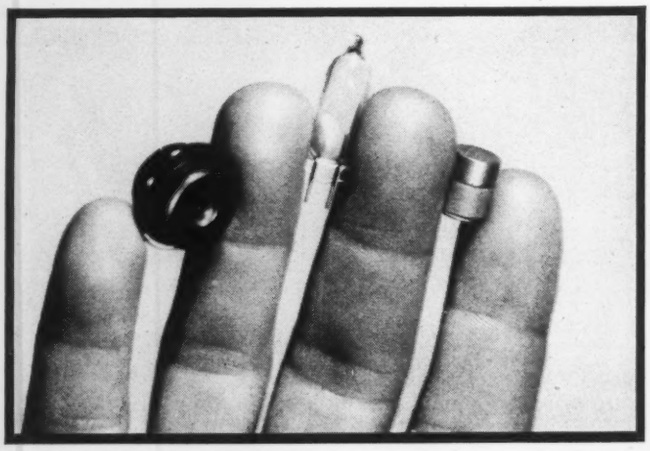
Anything and Everything for **GAS WELDING or CUTTING and ARC WELDING**

FAMILIARITY with General Electric's three-way line of small-size Kon-nec-tors helps designers of electrical equipment give customers products that provide long, satisfactory service at low cost. For these modern mercury contact devices, although inexpensive, may be operated millions of times with unvarying efficiency, no flashing, and no sparking. They include:



1 **THE NEW "BUTTON" TYPE** Kon-nec-tor, designed originally as a silent-operating wall switch, and adaptable to many types of use because of its unique compact size.

2 **THE LOW-PRICE GLASS** Kon-nec-tor of the single-pole, single-throw type with a mercury-to-metal contact. The Kon-nec-tor can handle loads up to 5 amperes.

3 **THE "PELLET" TYPE** of mercury contact, although only 3/8″ in diameter and 7/16″ long, has a 30-watt capacity on 12-16 volts at 3 amperes. Has a multitude of uses.

For further information about these low-cost G-E Kon-nec-tors, write or wire the address given below.

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GENERAL ELECTRIC

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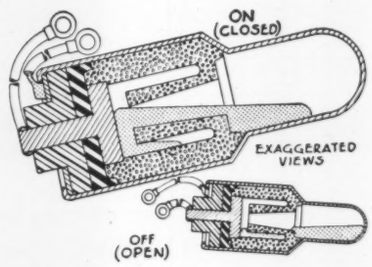
New PARTS AND MATERIALS

Double Flow Mercury Switch

DOUBLE-FLOW mercury switches in unbreakable metal having capacities of 10, 20, 35 and 65 amperes have been made available by Durakool Inc., 1029 North Main street, Elkhart, Ind., for national defense purposes—priorities being required. Double-flow has a peculiar characteristic which occurs at the time of opening and again at the time of closing or rejoining of the two bodies of mercury.



When the large end tips slightly above level, the horseshoe-shaped mercury pulls down on either leg, putting the central part of the mercury under tension, so that when parting takes place neither body can reach over and reconnect with the receding, opposite body. When the large end starts to tip back to closed position, the two separate legs of the horseshoe crowd toward a common joining point, and the mercury in a long channel compresses the advancing points so that when the two meet they become confluent with a level twice as high as they would if it were but one moving body of mercury contacting a stationary body.

Multidisk Floating-Plate Clutch

AVAILABLE in single or double type, either wet or dry plate, the new multidisk floating-plate clutches announced by The Carlyle Johnson Machine Co., 52 Main street, Manchester, Conn., are particularly adapted to machine tool and other industrial machinery applications. In the wet plate clutch, all plates are of hardened steel, to be run in lubricant; while in the dry plate clutch where no lubricant is used other than that inherent

ZINC IN DEFENSE-

NO. 2 OF A SERIES

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PAINT
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CERAMICS
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NICKEL SILVER
NO. 1 HULL PLATES

U. S. ARMY SIGNAL CORPS PHOTO

RUBBER "KEEPS THEM ROLLING"

"Heavy duty" does not adequately describe the severity of tire service on United States Army mobile units. But fortunately for the effectiveness of the Defense Program, destructive operating conditions do not present new problems to our tire producers. Rubber compounders in America have long since turned out truck tires that will meet just such requirements. The tougher the service, the greater the need for zinc oxide in the rubber compound—to provide heat resisting qualities and reinforcement against wear and tear.

Add to the above the fact that zinc oxide is essential in the activation of accelerators of vulcanization, and you have an idea of the importance of this material in the manufacture and performance of tires for Army use. Rubber is just one of at least a dozen major industries which are depending on zinc in one form or another to produce the myriad products pouring into the Defense Program. At the bottom of this page is a partial list of the *rubber* defense items in which zinc pigments are considered indispensable.

The uses for zinc in defense are the same as those in normal times, but the program calls for such quantities of zinc for certain products that non-defense consumers have not been able to obtain all of the zinc they would like to use. This is part of the price that must be paid for national security.

RUBBER SERVES DEFENSE IN:

Aviators Suits
Barrage Balloons
Gas Mask Carriers
Gloves
Life Preservers
Overshoe Boots
Parachute Cord
Protective Pads
Raincoats
Submarine Battery Separators
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And In Many Other Ways

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THE NEW JERSEY ZINC COMPANY

MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS

BOTH AMPCO-EQUIPPED!

Sleek, 400-mile-an-hour fighting planes and ponderous earth-moving equipment, both are equipped with AMPCO METAL, that sturdy alloy of the aluminum bronze class. Different types of applications, of course, but each dependent upon Ampco bronzes for protection against wear, impact, fatigue and other types of *metal failure*. Airplanes and power shovels are only two of the many diverse kinds of equipment regularly employing AMPCO. The range of uses of AMPCO bronzes extends through all industry. The wear-resistant qualities and high physical properties of the metal are recognized by performance-conscious engineers in key defense activities.

This versatile bronze has proven itself in machine tools, ordnance, aircraft, heavy machinery—wherever a bronze that can "take it" is needed. Investigate its use, when you have a metal problem. It is available in six grades of hardness and physical properties. Ask for Catalogue No. 22, or specialized literature.

AMPCO METAL, INC.
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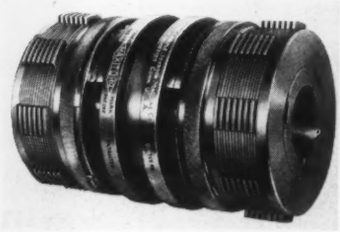
AMPCO LITERATURE Available

AMPCO METAL, catalogue 22
Ampcaloy—Industrial Bronzes Catalogue
Ampco-Trode Coated Aluminum Bronze Welding Rod
Ampco Metal in Machine Tools
Ampco Metal in Bushings and Bearings
Ampco Metal in Dies
Ampco Metal in Acid-Resistant Service
Ampco Metal in Aircraft
Ampco Metal Centrifugal Castings
Ampco Metal in Heavy Machinery
Ampco Metal in Gears

AMPCO METAL
The Metal Without An Equal
AMPCO

in the material itself, the plates are alternately steel and self-lubricating bronze.

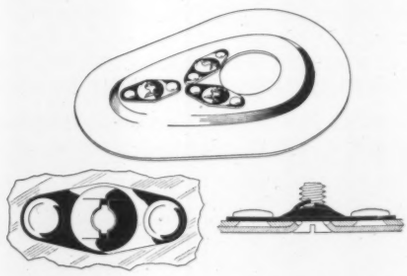
The double-type clutch is a compact, integral unit, and not a combination of two single clutches. Nonmetallic shoes with studs are supplied with each clutch, and are riveted into the engaging lever, preventing wear in shipper sleeve groove.



In neutral, no disk touches the ones adjacent to it because of the floating plates. A separate spring between each pair of inner disks spreads these endways with an accordion action so that light can be seen between all disks. The separator springs assure quick disengaging and prevent excessive drag, abrasion or heating. No oil release holes or radial grooves are required in the plates of this type of clutch. A locking plate on the disk end of each clutch (two on the double type) locks all disks against this spring tension. Counterclockwise movement of knurled adjusting ring removes this spring tension. Locking plate can be pressed endways slightly against the disks, when one-third of a turn of the locking plate releases it. This plate and all disks can then be removed, and the balance of the clutch taken apart.

Lightweight Aircraft Fastenings

AN EXTREMELY lightweight speed nut for blind mounting and flush-blind mounting assemblies has been developed by Tinnerman Products Inc., 2038 Fulton road, Cleveland. This new flat-anchor type nut is designed with a ball formation surrounding the prongs of the nut that is sufficient to span the standard dimpling for counter-sunk flat



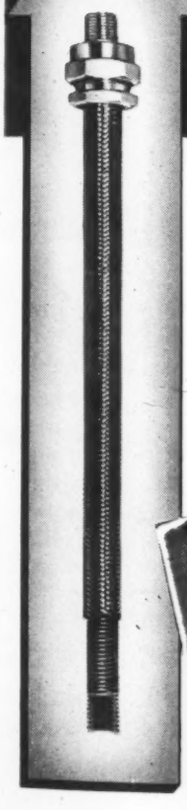
head screws or bolts. Offering an 80 per cent saving in weight, the nut can be used to advantage particularly in aircraft assemblies. In the accompanying illustration are shown three of the fastenings used in a navigation light mounting plate. At

900 Loaves Per Hour!

And batch after batch "done to a turn"

THANKS TO AMERICAN SEAMLESS FLEXIBLE METAL TUBING

Indirect oil-fired "Circulating Heat" De Luxe EC-TRI-FLEX tray oven made by the Petersen Oven Company, Chicago. Because this famous manufacturer must have a dependable *flexible fuel line, he uses American Seamless Metal Tubing exclusively.*



These and hundreds of other design problems involving flexible connectors for the conveyance of steam, air, oil and other liquids and gases have been solved by the products of American Metal Hose. The line runs from simple square locked metal hose to "American Seamless," the toughest tubing you can buy—available in various metals.

Ask for publication No. 40.

900 loaves of bread per hour—that's the capacity of this Petersen De Luxe EC-TRI-FLEX oven—enough bread to fill a day's requirement for a medium sized community. So you can picture the loss that would be incurred if infrequent cleaning of the oil burner resulted in unpleasant odors, improper combustion, uneven heat, and consequent failure of a baking.

But no danger of that happening here. The American Seamless Flexible Metal Fuel Line allows the hinged burner to be swung out *after each baking* for cooling and a thorough cleaning. There is no need for disconnecting the fuel line. As a result the burners are easily cleaned and receive better maintenance than "hard to get at" burners with rigid fuel lines. *American Seamless* is built to last, too. Its all-metal construction makes it impervious to the chemical action of oil and assures sturdy resistance to the intense heat encountered in this usage. It's as flexible as garden hose and as dependable as the rigid tubing from which it is made. Easily installed, it gives a neat, streamlined appearance to the burner. 41256

ANACONDA
from mine to consumer

Write for this 24-page manual on American Seamless Flexible Metal Tubing. Contains more than 75 pictures and charts explaining applications and availability. Ask for SS-25.

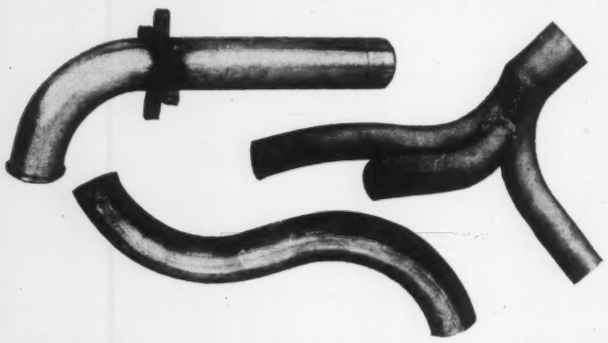
American Metal Hose

American Metal Hose Branch of THE AMERICAN BRASS COMPANY

General Offices: Waterbury, Conn. • *Subsidiary of Anaconda Copper Mining Co.*

In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ontario

HOW TO BEND
WELDED STAINLESS TUBING



• Published by Carpenter to help you get the most out of the Welded Stainless Tubing you are using.

Whether used for textile dye sticks, exhaust manifolds or any of a hundred other applications, Welded Stainless Tubing provides close gauge tolerances, strength and the ability to withstand severe service conditions.

Annealed, it is about 50% stronger than cold rolled steel, and nearly as ductile. However, certain precautions are required in bending.

- Use the best bending equipment.
- Bend over a form using a shoe with a groove of the same diameter as the diameter of the tubing.
- Use an inside mandrel or sand, lead, rosin or bending metal filler.
- Reduce bending speeds somewhat below those used for mild steel or brass and increase power accordingly.

Add these precautions to your standard rules for bending light wall tubing and the results should equal those obtained with mild steel—as the above photographs show.

For full instructions on the best means of handling Welded Stainless Tubing, see your Carpenter distributor or write us direct.

THE CARPENTER STEEL COMPANY
Department 11
Welded Alloy Tube Division
KENILWORTH, N. J.

ASK FOR THIS FREE FOLDER

Carpenter
WELDED
STAINLESS TUBING

lower right is a counter-sunk flat-head screw arrangement with nut riveted in position; while at lower left is shown a vertical view of the speed nut with its perfect-circle crown. The nuts are made of special molybdenum aircraft spring steel.

New Motor Starter Announced

GENERAL-PURPOSE starters of 2300 volts 60 cycles have been especially designed by General Electric Co., Schenectady, N. Y., for protection against short circuits and overloads. The control, which is completely metal enclosed for compactness, easy installation and safety, is composed of an oil-immersed contactor with self-cleaning copper tips, wide metal bearings, copper-braided shunts, and current-limiting fuses. Four standard types of this new starter are available, providing for full-voltage

starting, reduced-voltage starting, and reversing of squirrel-cage motors and synchronous motors. Also available are starters for special applications.

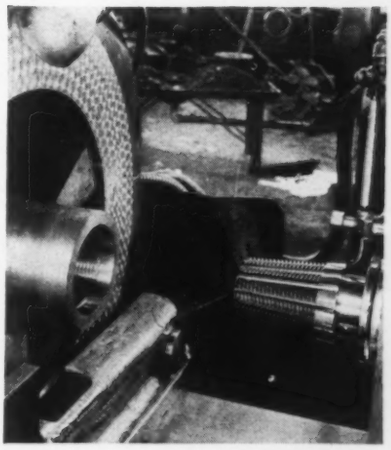
By the use of current-limiting fuses, which limit short circuit current in less than ¼ cycle, and open in less than ½ cycle, the starters offer complete protection against short circuits. The fuses have a disconnect feature, making possible complete isolation of an individual starter without causing the entire motor line to be shut down. Protection of motors against over-loads is by isothermic relays which operate in case of locked rotor, single-phasing or sustained overload. Under-voltage protection is provided; on low voltage or loss of power the line contactor opens and on return of power the motor will not restart until the pushbutton is operated.

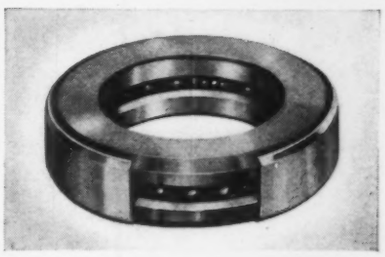
Actuator for Switches

FOR use with both its alternating and direct-current switches, the Mu-Switch Corp., Canton, Mass., has developed its new Type Y actuator which comprises a nickel-steel arm carrying at one end a graphite impregnated, self-lubricating bakelite roller and pivoted on an oilless bearing at

IN THE NEWS
WITH BANTAM BEARINGS

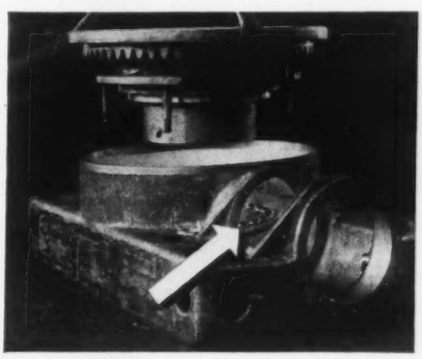
WORLD'S LARGEST POWER SHOVEL, built by The Marion Steam Shovel Company, is provided with a dipper having capacity of 35 cubic yards. Unit shown is in coal stripping service at Tecumseh Coal Corporation. Hoist motor extension shaft of this giant shovel turns on Bantam Radial Roller Bearings measuring 15.25" O.D., having self-aligning features that simplify assembly.



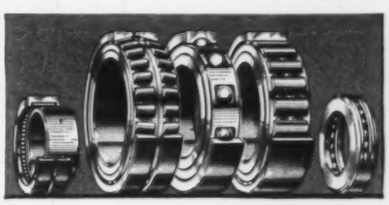


THRUST LOADS UP TO 40,000 POUNDS are carried by Bantam Ball Thrust Bearings, measuring 16" O.D., in this heavy-duty milling machine built by Smalley-General Company. Loads occur in the air cylinder actuating the chuck that holds the work, and are transmitted to the main spindle by a draw pipe. With the Bantam Bearings, the spindle is driven at 50 to 60 R.P.M. by a 5 HP motor—without the bearings 20 HP would be needed. Bantam Bearings have been used on these machines for periods as long as 15 years—without a single case of bearing failure.

A NEW UNDERSEA CRAFT joins the nation's expanding fleet as the Triton is launched at the Portsmouth Navy Yard. Many of America's submarines are equipped with special bearings built by Bantam for this exacting service—bearings of K-Monel metal, for example, that resist the corrosive action of salt air and water.



THE SEARCH FOR OIL goes deeper into the earth, subjecting drilling equipment to heavier loads and severer service. Typical of the equipment designed to meet today's needs is American Well & Prospecting Company's 17½-inch "Gumbo Buster," shown ready for assembly. Rotary table turns on specially designed Bantam Ball Thrust Bearing.

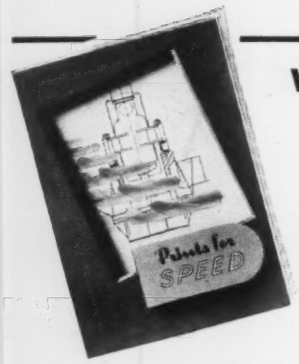


BANTAM MAKES EVERY MAJOR TYPE of anti-friction bearing—straight roller, tapered roller, needle, and ball. Newest addition to Bantam's comprehensive line is the compact, high-capacity Quill Bearing, designed for easy installation, long life, and thorough lubrication. For information on any type of anti-friction bearing—for unbiased counsel on the selection of bearings, TURN TO BANTAM.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA



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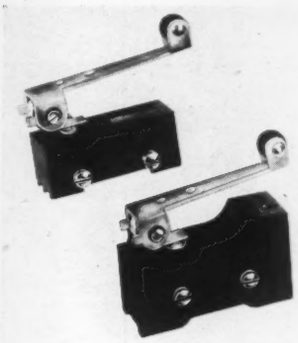
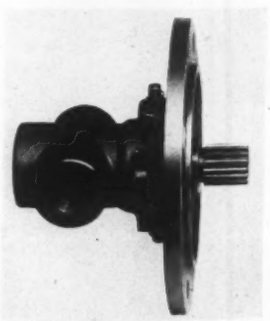
the other end. A "U" spring of phosphor bronze, riveted to the under side of the arm, transmits actuating force to the operating button of the switch and absorbs excess movement at the roller. Advantages of ⅜-inch over-travel, large reduction in effective operating pressure, and construction



suited to high speed cam operation enable the new actuator to provide a versatile means of adapting the precision switches, to which they are attached, to a wide variety of applications. Design of the attachment bracket permits the actuator to be applied with equal facility to either side of the standard type and the heavy-duty type switch produced by the company.

Hydraulic Circulating Pump

FOR pumping ethylene glycol at high temperatures and high discharge pressures, Model RD-4330 circulating pump has been introduced by Romec Pump Co., Elyria, O. The rated capacity of this nonpulsating pump is 2½ gallons per minute at 2700 revolutions per minute, pumping a mixture of 15 per cent glycerine and 85 per cent ethylene glycol by weight at 200 degrees Fahr. and 100 pounds per square inch discharge pressure. Precision built and designed for either direction of rotation, the pump is engineered on the same principle as the company's recently announced nonpulsating fuel pumps. It has a rotor mounted eccentrically in a developed bore with one-piece sliding vanes carrying sealing-rockers that maintain a broad contact with the bore wall at any angle of the vane. The driveshaft seal incorporates a compression spring and is hydraulically loaded by the pressure within the pump. It is also cushioned and self-lubricated. The flexible coupling compensates for axial and



OF *Interest and Value* TO ENGINEERS AND TECHNICAL MEN!

A COMPLETE TABULATION OF STAINLESS STEEL ANALYSES

Through constant research, experiment and specialized attention to the particular needs of the process industries, Globe Stainless Tube Co. has acquired a valuable fund of engineering and metallurgical data. We are prepared to furnish comprehensive information to chemical, food, paper, oil, and other process industries on the service to be expected from stainless steel tubes of varying analyses.

Globe Stainless Tubes, including corrosion and heat resisting seamless tubing and pipe are available in a wide range of chrome and chrome-nickel alloys. These tubes are in use on some of the largest industrial installations — are the choice of leading equipment makers. Write for "Analyses Chart" Bulletin I-G —a complete tabulation of stainless steel analyses as produced by various manufacturers.

GLOBE STAINLESS TUBE CO • 4009 WEST BURNHAM STREET • MILWAUKEE, WISCONSIN

STAINLESS TUBES
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CONDENSER AND
HEAT EXCHANGER TUBES
MECHANICAL TUBING

GLOBE STEEL TUBES
Stainless for Security
Seamless for Safety

Selecting Special Motors

WHAT must I know about motors? . . . What are their advantages and disadvantages? . . . What type should I use? These and many more problems relative to specification and use of special motors are discussed by recognized authorities in the 48-page booklet, "Selecting Special Motors".

Originally printed serially in MACHINE DESIGN, these nine articles have been reprinted in a convenient form so that the facts of special motor selection will be immediately available within a single cover.

CONTENTS

Part I —Mountings and Enclosures, by C. W. Drake
Part II —Small Reversing Motors, by W. M. Yogerst and C. A. Rall
Part III —Lightweight D. C. Motors, by W. H. Fromm
Part IV —Multispeed Induction Motors, by J. H. Fortenbach
Part V —Frequent Starting and Reversing Motors, by R. J. Owen and J. J. Kirkish
Part VI —Short Time Rated Motors, by G. R. Anderson
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Price: Fifty Cents Postpaid

MACHINE DESIGN

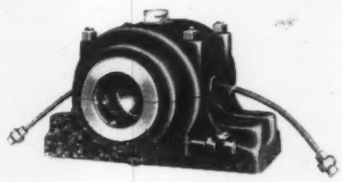
PENTON BUILDING
CLEVELAND, OHIO

angular misalignment of the shaft. Another heat-resisting seal prevents engine oil from leaking into the pump along the shaft. Weight of the pump, which is now being used as standard equipment with aircraft cabin heating systems, is 2 pounds, 12 ounces.

Babbitted Pillow Blocks

IN PLAIN and watercooled types and in shaft sizes from 1-7/16-inch to 8 inches inclusive, a new Sleeveoil precision pillow block has been introduced by Dodge Mfg. Co., Mishawaka, Ind. These selfaligning bearings can be furnished in either expansion or nonexpansion types; the former has a provision for thrust loads, while the latter is supplied with two internal split thrust collars.

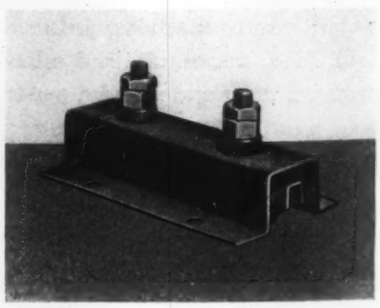
The watercooled pillow blocks, illustrated, are identical in design and construction with the plain



type except for the watercooled feature which makes it particularly adaptable for use where elevated temperatures, heavy loads or rubbing speeds are encountered. Sizes up to and including 3-15/16 inches are watercooled in the lower liner only and have one flexible inlet and one outlet connection. Sizes 4-7/16 inches and larger are watercooled in both upper and lower liners and have two flexible inlet and two outlet connections. Both plain and watercooled types can be obtained in sizes up to and including 3-15/16 inches.

Rubber Isolators for Low Loads

SEVERAL new types of isolators, employing rubber as a cushioning medium, have been introduced by Korfund Co. Inc., 58 Thirty-second place, Long Island City. These isolators can be included in



small engines and relatively lightweight machinery, and for scientific isolation of vibration and noise in the lower loading ranges. Load capacities of the shear type mounting for individual units range from

MINERAL OIL. Most tracing papers are treated with some kind of oil. Mineral oil is physically unstable, tends to "drift", never dries completely. Papers treated with mineral oil pick up dust, lose transparency with age.

VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.

ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent, Albanene is unaffected by harsh climates —will not oxidize with age, become brittle or lose transparency.

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A remarkable new transparentizing agent developed in the K & E laboratories—produces this truly permanent tracing paper! ALBANENE is made of 100% long fiber pure white rags—treated with *Albanite*—a new crystal clear synthetic solid, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Equally important, ALBANENE has an excellent drawing surface that takes ink or pencil beautifully and erases with ease . . . a high degree of transparency that makes tracing simple and produces strong sharp blueprints . . . extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you've always wanted—and *it will retain all these characteristics indefinitely.*

Make ALBANENE "prove it" on your own drawing board. Ask your K & E dealer or write us for an illustrated brochure and generous working sample.

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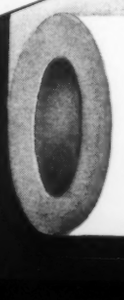

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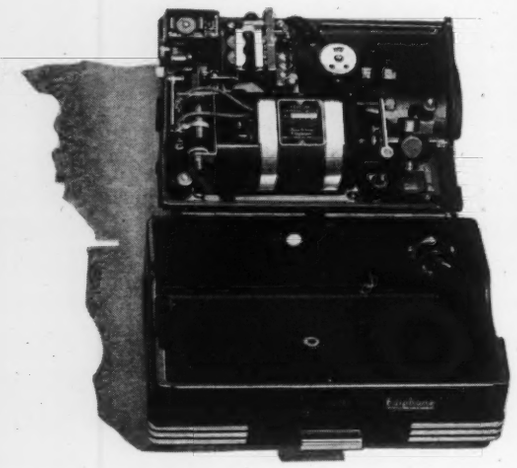
THE STABILIZED-TRACING PAPER

Irv-O-Volt **INSULATION**



AIDS *Ediphone's* **EFFICIENCY**

As a protection and insulation of the electric magnet, sanitube switch and motor in the Ediphone, Thomas A. Edison, Inc. uses IRV-O-VOLT Varnished Inside-and-Out Tubing.

IRV-O-VOLT, because of its resistance to heat, moisture and wear, assures long life. Electrical, radio and instrument manufacturers demand a flexible varnished tubing, thoroughly impregnated and varnish coated inside and out, which will meet all published standards and specifications.

IRV-O-VOLT fulfills this need. Its flexibility with high tensile strength meets every bending, twisting, pulling and other assembly requirements. Because of its smooth inside surface, it slips easily over wires, permitting rapid snaking and fishing. Has high heat endurance, will not soften, blister or flow.

Comes in two grades of dielectric strength. Standard colors are black and yellow with green, brown, red, and blue on special order.

For more data Write Dept. 86

Irvington VARNISH & INSULATOR CO.

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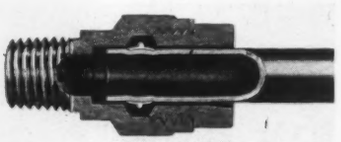
Representatives in 20 Principal Cities

25 to 450 pounds. Two or more mountings may be combined in steel housings when greater load capacities are required. The compression type mounting is suitable for concentrated loads and wherever the lesser deflection of rubber-in-compression is permissible. Both top and bottom steel sections are securely bonded to the circular rubber stock, for which type of mounting the load capacities range up to 1200 pounds per mounting. The unit may also be used as a shear-mounting, if desired, by bolting the base plate in a vertical direction.

High Pressure Flexible Fittings

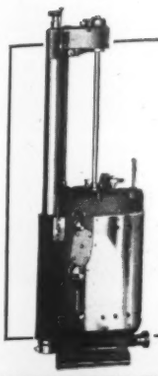
ANNOUNCED by Harris Products Co., 5423 Commonwealth avenue, Detroit, a new line of tube fittings using an insulating, flexing medium of rubber or synthetic, has a high pressure capacity rating and the flexibility of a tube-to-fitting connection. The connection does not depend upon the shear strength of the rubber or synthetic and eliminates the possibility of pressure swaging down



the end of the tube to cause failure of the connection. The new fittings can handle high pressures while permitting vibratory flexing up to 10-degrees included angle, and are available in a wide range of sizes for handling any fluid. They can be used for air, gas, gasoline, refrigerant, etc., and are supplied with standard pipe threads. For use under conditions requiring wide angle flexing or high vibration frequencies, or in applications where sound transmission must be reduced, the ferrule must be "rolled-in" with the tubing. The rubber insulator is placed over it and the rest of the fitting assembled in the usual manner.

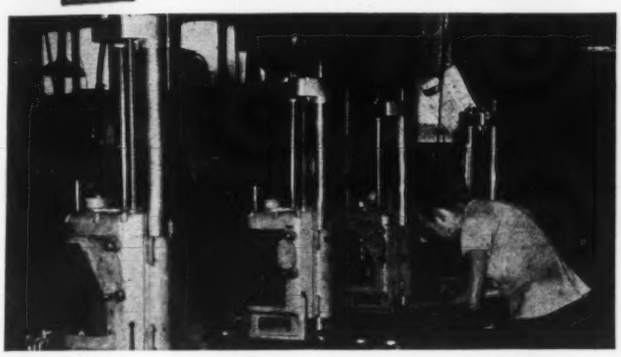
Plywood Substitutes for Metal

RECENT development of Technical Ply-Woods, 228 North LaSalle street, Chicago, specializing in plywoods for transport and industrial use, is its Fybr-Tech plywood, a new substitute for sheet

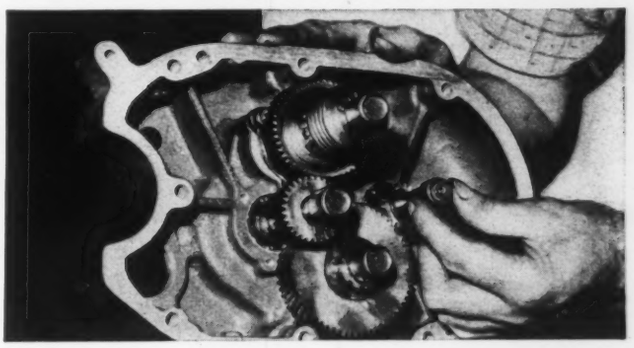


"30% DEEPER CUTS"

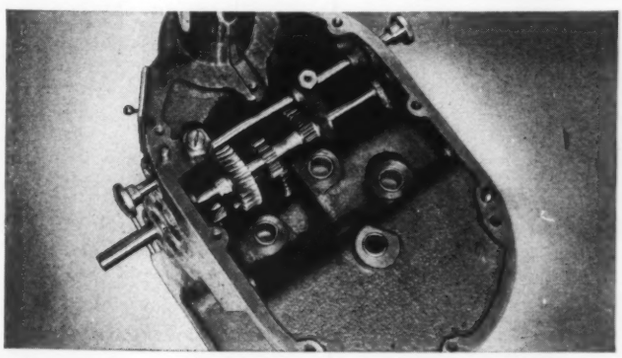
WITH COMPACT, ANTI-FRICTION TORRINGTON NEEDLE BEARINGS



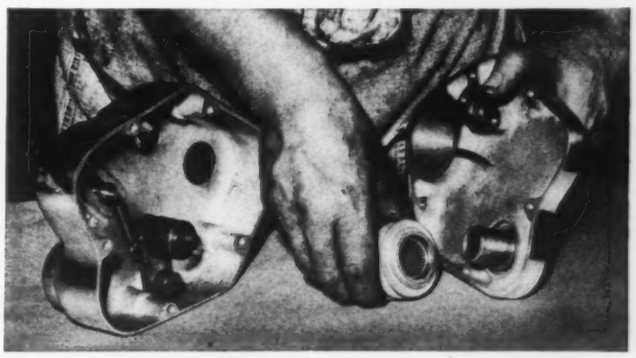
1 CYLINDER REBORING MACHINES, such as these, do a precise, quick, thrifty job of rejuvenating automobile engines. The unusual accuracy and economy of this "Stormizing" equipment are achieved largely through the use of Torrington Needle Bearings, it is reported by engineers of Storm Manufacturing Co.



2 HERE'S THE INSIDE STORY. Six anti-friction Torrington Needle Bearings on the gear shafts occupy no more space than plain bushings, "yet," states Storm, "they permit the machines to make 30% deeper cuts. And they help assure the even flow of power to cutter required for high speed precision boring."



3 SMALL, AREN'T THEY, these Torrington Needle Bearings in the main frame! Compact Needle Bearings can be easily adapted in many instances to existing housings or designs. In this way, efficient and dependable anti-friction operation is obtained while keeping surrounding parts small in size and light in weight.



4 THE CROSS HEAD, TOO, operates efficiently on Torrington Needle Bearings. Their hardened steel construction and large capacity for storage of lubricant provide extra long service and eliminate the need for frequent attention. And, says Storm, "installation costs as well as initial bearing costs are very low."

Your product, too, may gain by the important advantages of the Torrington Needle Bearing: high radial load capacity; small size; lasting lubrication; quick installation, and interestingly low costs. Our Engineering Department will

be glad to give you full assistance. For more detailed information, write for Catalog No. 109. For Needle Bearings to be used in heavier service, write our associate, Bantam Bearings Corporation, South Bend, Indiana, for Booklet 104X.

THE TORRINGTON COMPANY, TORRINGTON, CONN., U. S. A. • ESTABLISHED 1866

Makers of Needle and Ball Bearings

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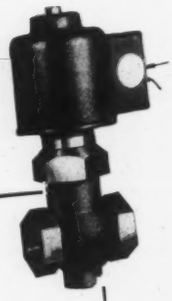
TORRINGTON NEEDLE BEARING

...When you need a *better* Solenoid Valve *remember* . . .



THIS

ASCO VALVE

HAS OPERATED MORE THAN

2,096,640 TIMES

ON A

Wood Automatic Autoplate

. . . and is still going strong!

ON—OFF— . . . on—off, four times a minute, six hours a day, seven days a week, fifty-two weeks every year for four years—without failure.

That's the success story of the Asco Solenoid Valve that controls the vacuum on the first Wood Automatic Autoplate installed to cast stereotypes for the New York Times.

This isn't the only newspaper plant using Wood Autoplates, of course—nor is this the only Asco Valve in such service. Because of its record, this valve is now standard equipment on every Wood Junior and Automatic Autoplate.

When you have a perplexing problem involving the automatic or remote control of steam, air, liquids or gases, remember there are more than fifty types of solencid valves in the complete line of Asco Valves. One of them will meet your requirements.

Automatic Switch Co.

49 East 11th St., New York City

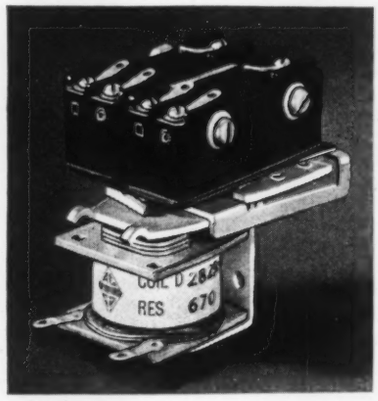
TELL US WHAT YOU WISH TO ACCOMPLISH

11-AS-2

metal. This material consists of plywood with vulcanized fiber resin-bonded to either or both faces. It is light, strong and easy to work; it may be die-cut, punched, drilled and bent to a radius of as little as one-half inch. It is furnished ready sanded and will take a fine paint finish. Among the applications for which it is either being used or tested are airplane wings, fuselage, interior linings and partitions on all types of transport vehicles, and casings for such widely diversified units as refrigerators, carpet sweepers, etc.

Relay Has Microswitch Contacts

TO MEET a demand for a heavy-duty relay having electrical contacts with larger current-carrying capacity, Automatic Electric Co. has announced the addition of a new, type 16 relay with microswitch contacts for alternating or direct current operation. The relay is sensitive, with easy-acting contacts designed for handling heavy loads



(alternating current only) up to 10 amperes, with small controlling currents. It can be furnished with one or two microswitches, each with make, break or break-make contacts, or with one break-make microswitch and one break-make spring assembly with code No. 2, No. 4 or laminated silver contacts. The maximum operating voltage is 230 volts either direct current, or 50-60 cycle alternating current. It is specifically recommended for locations subject to sudden jarring, constant vibration, or tilting, or for use on any type of machine where a quick-acting relay, with a minimum of arcing is desirable.

Engineering Dept. Equipment

Highly Transparent Tracing Cloth

ON THE new white tracing cloth developed by The Frederick Post Co., Box 803, Chicago, good, clear blueprints can be made from pencil tracings. The cloth has a specially-processed velvety surface which takes pencil perfectly. It is

IN DESTRUCTIVE ATMOSPHERES
Protect Your Production Line With

Century Totally Enclosed Fan Cooled Motors

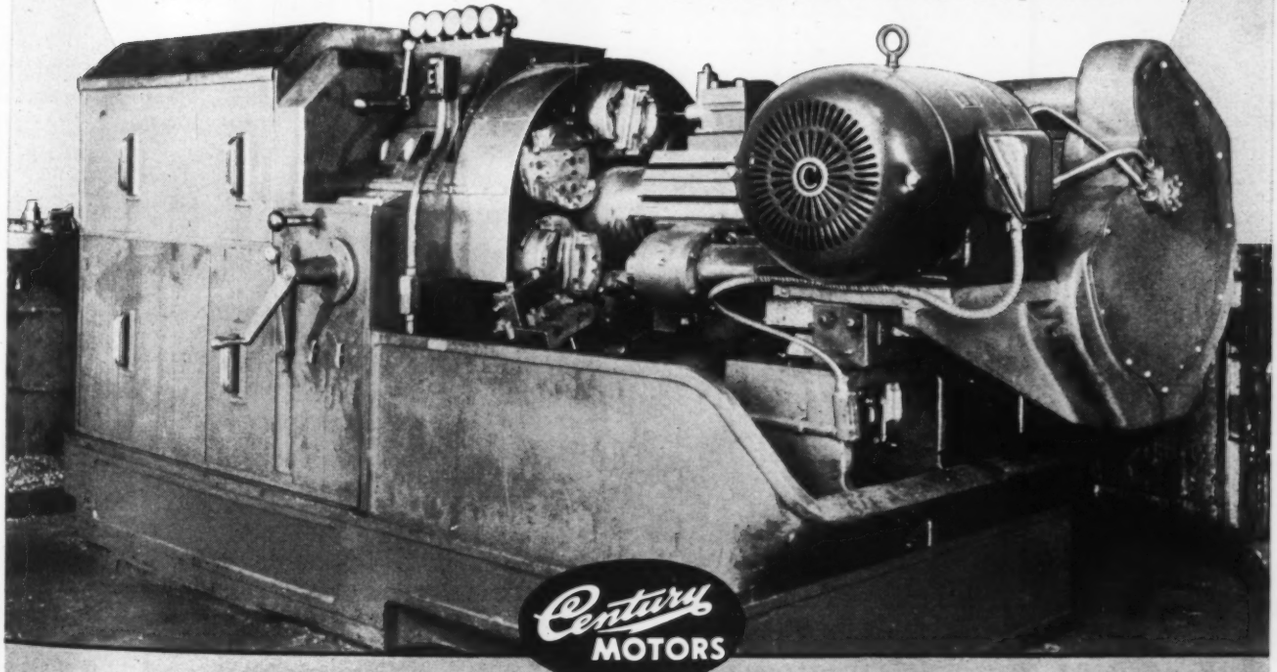
They are designed to safeguard the motor from the destructive effects of air that is fogged with metal cutting oils, or atmospheres containing abnormal quantities of metallic, abrasive, or other dusts—conditions that might ultimately destroy the insulation or clog the windings of a general purpose open motor.

The fan inside the pressed steel fan housing produces a blast of air flowing between the cast iron frame and the laminations, that not only cools the motor but also keeps the large air passages clean.

The modern, streamlined appearance of these new motors matches the trend of present day equipment design—they are easy to clean outside.

If atmospheric conditions are a problem in your plant, consult your nearest Century Motor Specialist. His experience with similar problems may well save you time and money — and help to keep production rolling during these critical, high pressure days.

CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis, Mo.
Offices and Stock Points in Principal Cities



One of the Largest Exclusive Motor and Generator Manufacturers in the World

CYLINDER FEATURES that mean better use of air power

Hannifin Pneumatic Cylinders combine advantages that help you get the most out of air power—precision construction and simple outside adjustment for maintaining high efficiency piston seal. Hannifin cylinders, including even the largest sizes, are bored and honed, producing a straight, round, perfectly smooth cylinder bore. This allows a superior piston fit that prevents leakage and reduces friction loss to the minimum.

Simple outside adjustment of piston packing allows easy maintenance of the efficient piston seal. The soft, graphite-treated piston packing can be adjusted whenever necessary, from outside the cylinder, without disturbing any other parts. The original high efficiency piston seal can be easily maintained throughout the entire life of the packing.

Hannifin Pneumatic Cylinders are built in a full range of standard mounting types, sizes 1 to 16 inch bore, for any length stroke. Both single and double-acting types, with or without cushion. Larger sizes built to order.

Write for Bulletin 34 with complete specifications.

HANNIFIN MANUFACTURING COMPANY
621-631 South Kolmar Avenue • Chicago, Illinois

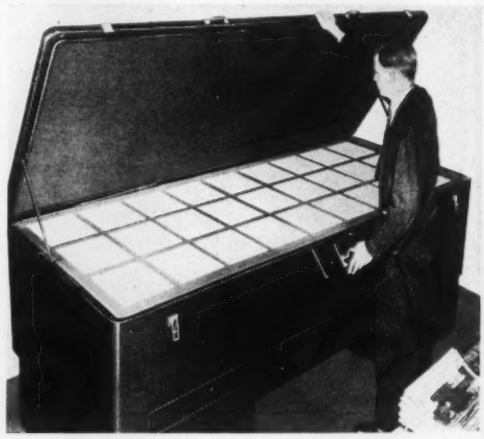
16 inch x 7 foot honed cylinder bore

HANNIFIN
PNEUMATIC CYLINDERS

tough, durable and will not discolor with age. An added feature is its glossy back, and the extra transparency adds speed to print production. Because of this high degree of transparency and the texture that results in "ink-line" density from hard pencil, positive prints can be obtained as well as knife-sharp major contrast blueprints from pencil drawings. The cloth erases quickly and cleanly and takes colored pencils sharply.

Contact Photocopying Equipment

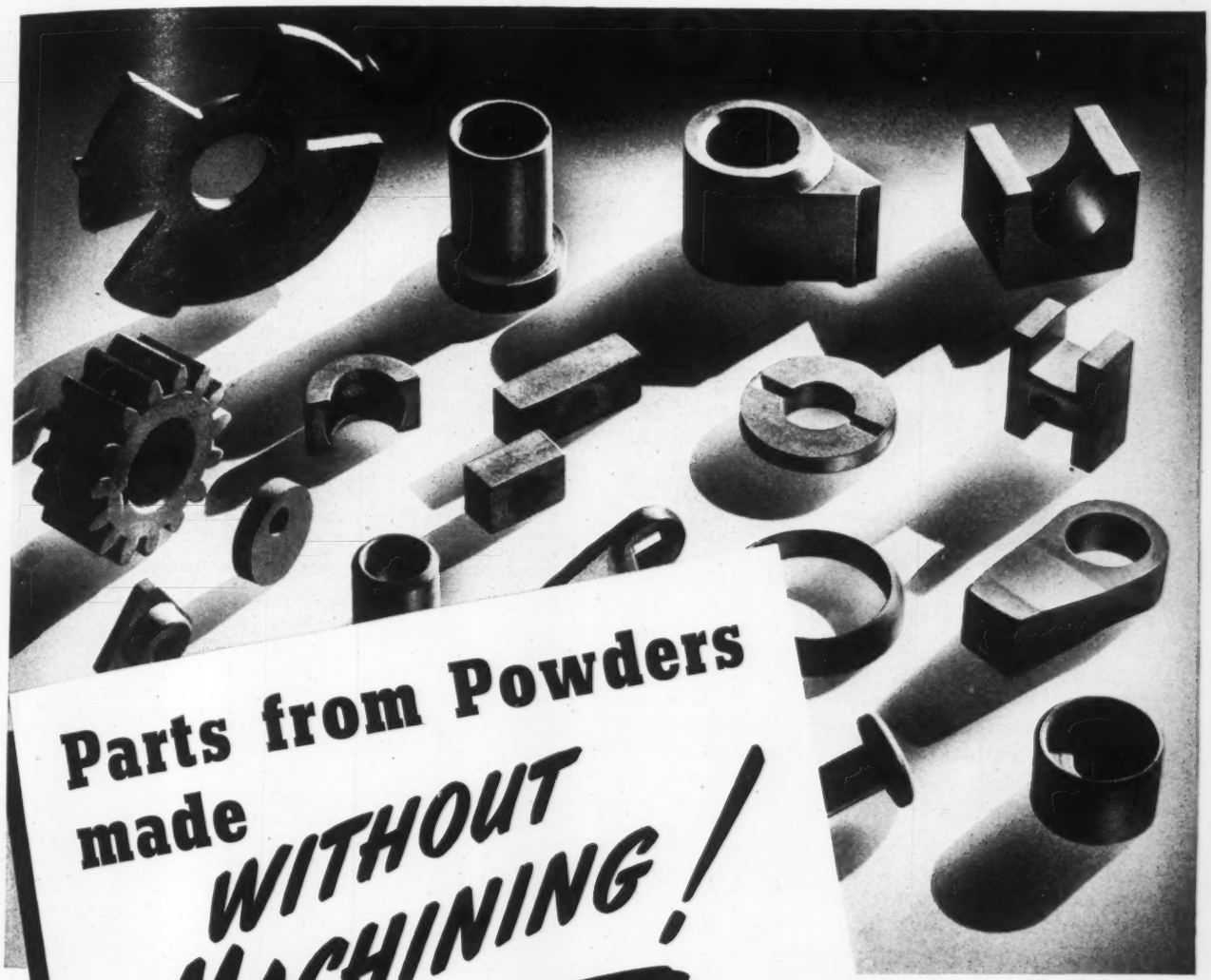
ANNOUNCEMENT has been made recently of new contact photocopying equipment, by Hunter Electro-Copyist Inc., Syracuse, N. Y. The unit employs photocopying processes involving a horizontal bank of both white and amber lights beneath a ground glass on which the sensitized paper and matter to be copied are held firmly in contact by high vacuum, created by a self-contained motor-driven pump. A drawing 36 x 88



inches can be accommodated, or multiple printing can be done as shown in the accompanying illustration. This model is a special size adaptable to a wide variety of drafting room work. This machine can be supplied in other models to suit particular purposes.

New Pencil Tracing Cloth

COMPLETING its tracing cloth line of ink, white pencil, and blue pencil cloth, Holliston Mills Inc., Norwood, Mass., has introduced a new pencil cloth which has a greatly improved surface. The process of manufacture assures tracing cloth conforming to the highest recognized standards. The cloth is available in the standard 24-yard rolls, each roll being packed in a dust and moisture-proof box eliminating the possibility of damage from atmospheric conditions or waste in handling. Special size rolls, cut sheets, printed sheets or larger working samples can also be obtained. This new pencil cloth is made to take pencil or ink without loss of erasable, clean line qualities.



Parts from Powders made WITHOUT MACHINING!

Small parts engineered by Moraine from iron powders have opened up new design possibilities, substituted for scarce materials, and eliminated machining operations for scores of manufacturers. For example, in a machine saw guide-block, Durex Iron replaced hardened and ground steel at lower cost, provided self-lubrication and excellent wear-resistance. Durex Iron cams and other parts of complex shapes are made to close tolerances without machining. Moreover, smooth finish, self-lubrication, and high wear-resistance make Durex Iron suitable for many bearing applications, frequently replace bronze bearings at lower cost. Check powder metallurgy as applied to your problems. Write for new bulletin on Durex Iron: Form 102 D.

MORAINE

Pioneer in Powder Metallurgy

MORAINE PRODUCTS DIVISION, GENERAL MOTORS CORPORATION, DAYTON, OHIO

IN WAR...AS IN PEACE
Arkwright stands for quality!

Whether American industry is producing the weapons of war or the tools of peace, Arkwright stands ever ready to meet industry's needs with the same high quality tracing cloth!

Years of testing in Arkwright laboratories . . . years of insistence on highest quality materials and highest standards of manufacturing have prepared Arkwright for the present emergency. Today, you can order Arkwright tracing cloths with the same confidence in quality . . . the same assurance of rapid delivery that has given Arkwright its recognized position as the leading American producer of tracing cloth for over twenty years! Arkwright Finishing Co., Providence, Rhode Island.

Arkwright
TRACING CLOTHS

Metallurgists Rescue The 1942 Automobile

(*Continued from Page* 53)

molybdenum, a purely domestic metal, in large amounts; silicon, plentifully abundant in the earth's crust; and some highly specialized deoxidizing and nitrogen-fixing alloys which, used in small quantities, exert a tremendous influence on hardening power. These include titanium, aluminum, zirconium, vanadium and calcium.

To be more specific regarding these low-alloy steels and their hardening power or hardenability compared with the higher alloys and with plain carbon steels, *Fig.* 3 and *Fig.* 4 have been presented by Mr. Boegehold, illustrating how cooling rates affect the hardness of nine steels. *Fig.* 3 shows SAE 4340, a chrome-nickel-molybdenum steel such as used for large axle shafts and other heavy parts; 1340, a high-manganese steel; X-1340, another grade of this manganese steel, and 1040, a plain carbon steel.

Equivalent Hardening Obtained

The same information for some of the newer steels without chromium, nickel or more than one per cent manganese is given in *Fig.* 5. It may be seen that these steels possess degrees of hardenability making them suitable for replacing steels shown in *Fig.* 3. Amola is the trade name applied to a series of steels developed some years ago by Chrysler metallurgists and now used widely for various mechanical parts in Chrysler cars. Grainal is the trade name of a special deoxidizing treatment given to carbon steel in open-hearth processing.

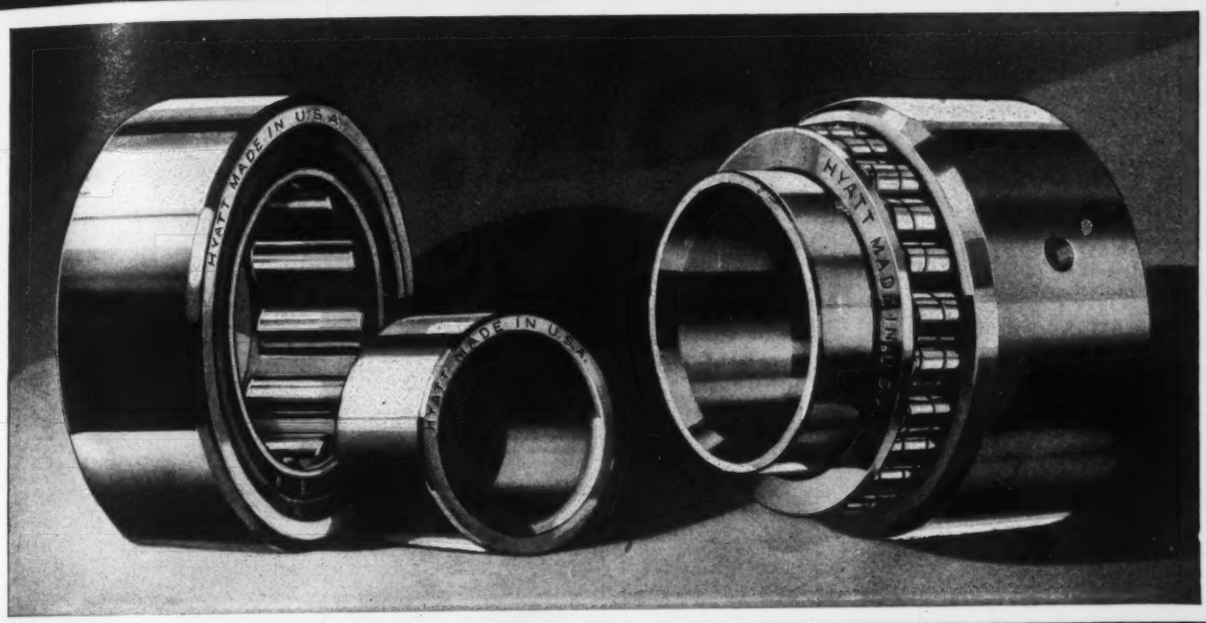
Readjustments in heat treating and machining procedures undoubtedly will be made as the uses of these newer steels become more general, but the important fact is that the engineer will not be required to redesign operating parts to compensate for the change to steels free from alloying elements which are now reserved for "defense."

Plastics Replace Metals

Some of the most interesting work done in Chrysler engineering laboratories in recent years has been a concerted study of the possibilities of synthetic materials in automotive applications. While the study is still in its infancy, progress has been made to such an extent that it has been possible to make immediately available optional materials for several applications. Thus, aluminum has been adequately (though perhaps not economically) replaced in the engine oil-seal plate, *Fig.* 5, by a plastic with steel inserts for threads. These plates do a good job of sealing, allow good production control and are 40 per cent lighter than the aluminum plates, even with increased thickness.

Door handles, formerly zinc alloy die castings,

KEEP THEM YOUNG WITH HYATTS



NO MATTER WHAT THE APPLICATION

THEY ALL GO FOR HYATTS BECAUSE HYATTS KEEP THEIR EQUIPMENT GOING!

Wherever wheels and shafts turn, Hyatt Roller Bearings are carrying the load . . . cushioning the shocks . . . minimizing friction . . . and keeping equipment young and ever on the go. Build these dependable bearings into the machines you manufacture, look for them in the equipment you buy, and let us give you any further data desired. Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey; Chicago, Pittsburgh, Detroit and San Francisco.

HYATT

ROLLER BEARINGS

QUIET

IN DEFENSE
of your product's
REPUTATION

IT TAKES YEARS to build a reputation.

Yet, in a short time, through the use of inferior materials, parts or units (due to the speed and stress of National Defense) a product or equipment can lose its high standing.

Despite high-peak production, BALDOR will continue to be a quality-built motor. The highest standard of materials and workmanship will be maintained; the inspection staff larger and more vigilant.

When we defend our reputation, we also defend yours—if you use Baldor Motors.

BALDOR ELECTRIC COMPANY, ST. LOUIS
Representatives in Principal Cities

BALDOR
BETTER MOTORS

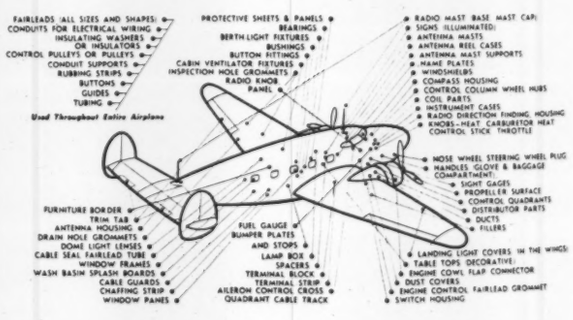
have been redesigned for thermoplastic materials injection molded around a steel insert. These plastic door handles, *Fig.* 5, are blended with interior color schemes and have a decided advantage over zinc in that they suffer little loss of strength at subnormal temperatures. Zinc die castings, Chrysler engineers report, lose approximately 75 per cent of their strength as well as much of their impact resistance at —10 degrees Fahrenheit.

Problems of motor car engineers in working out substitutions, or alternate materials, are not altogether concerned with the available supply of materials. On this point Mr. McCarroll lists six other factors which have been taken into consideration by his organization. They are:

1. Effect of changes on resulting quality
2. Effect of changes on costs
3. Effect of tooling requirements
4. Effect on man-hour requirements
5. Possibility of design changes facilitating a switch in materials
6. Possibility of alternate manufacturing methods facilitating a change in materials.

The first four are obvious considerations and, in changes so far developed, the result has been a maintenance of quality but an increase in costs principally due to increased tooling and labor. The matter of design changes was referred to previously in reference to exhaust valves. The last factor is worthy of some mention. An example is the work which Ford has done in centrifugal casting of steel as an alternate method to forging.

Transmission gear clusters are being made by the centrifugal casting method and Ford is now in process of setting up equipment to produce defense parts such as aircraft engine cylinder barrels, airplane landing gear hinges and other heavy pieces.



Increased pressure on engineers and designers in airplane manufacturing companies has greatly accelerated the trend toward the utilization of plastic parts in planes. Older applications of thermosetting plastics are being rapidly extended. In addition, manifold uses of transparent acrylic resins, (Lucite), are being found as indicated in the accompanying composite chart. Examples of such transparent plastic parts are windshields, windows, turrets, navigation "blisters", etc. Their resistance to shattering and the facility with which they may be formed into air-foil sections greatly simplify the designers problems for such parts.

A NEW, Low-Cost Light Steel Structure

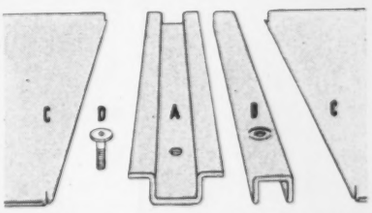
Here is a new, patented all-steel housing—known as Lindsay Structure—in which the panel sheets are "pre-tensed" to reinforce the framing members. Thus, every ounce of steel in Lindsay Structure contributes all its strength. Cross braces, gussets, and struts are unnecessary, and light sheets and framing can be used without sacrificing strength or rigidity.

The sheets and framing in Lindsay Structure are fastened without rivets or welds. They can be assembled or disassembled with small wrenches, as easily as the simplest bolted construction.

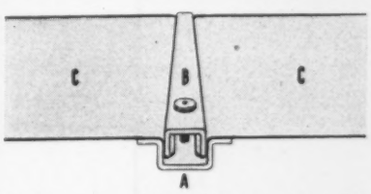
Parts for Lindsay Structure are die rolled, die drawn, and die cut to 4500 standard sizes, within ½ inch of any desired dimension. As they are made by quantity production methods, the cost of Lindsay Structure is low. Assembly is quick and inexpensive.

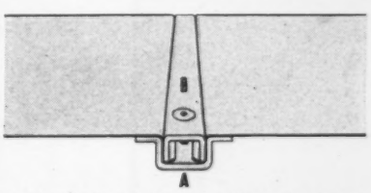
Lindsay Structure has a smooth surface that makes a very attractive appearance. It is available in plain, galvannealed, or enameled finish. Ideal for air-conditioning housings, dryers, furnace housings, coolers, shipping containers, truck bodies, marine and railroad uses, etc. Investigate this new and remarkable structure for your product.

How Lindsay Structure gets EXTRA STRENGTH without extra weight

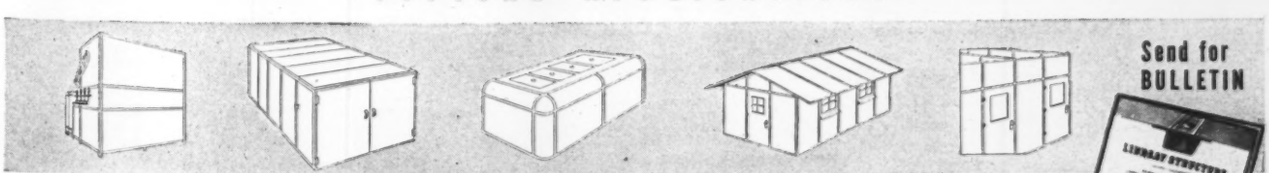


Lindsay Structure elements: (A) flanged frames; (B) tensioner; (C) steel sheets with drawn edges; and (D) socket lock screw. The tensioner grips the edge of the sheets and the socket screw draws it into the frame. This patented construction brings the sheets into tension and provides a unified structure of amazing strength and rigidity.





TYPICAL APPLICATIONS



Housings | Ovens | Containers | Buildings | Partitions

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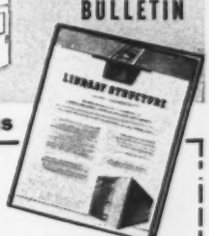

LINDSAY STRUCTURE

U. S. PATENT 2017629
U. S. and Foreign Patents Pending

Parts for Lindsay Structure are Die Rolled, Die Drawn, and Die Cut

Dry-Zero Corporation
Lindsay Structure Division
228 North Bank Drive, Chicago, Ill.

Please send me further information on Lindsay Structure.

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450

With the New Venturi-Type FAN HOUSING

FOR THE FIRST TIME in the air conditioning field, a Presteel Fan Housing with the Venturi Section drawn down in one operation, is available as a standard item.

Increase the fan efficiency of your air conditioning system. Send today for the free folder and price list that give the full story of this new Commercial Fan Housing—its features, sizes and gauges available for exhaust fans, ventilating fans and unit heaters.

The COMMERCIAL SHEARING & STAMPING COMPANY

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TUTHILL PRECISION-BUILT PUMPS FOR YOUR REQUIREMENTS

For defense and normal requirements, you can depend on Tuthill positive displacement internal gear rotary pumps. Every pump is precision-built and job-engineered for specific applications to give you dependable, economical long-life performance. Capacities from ¼ to 200 g.p.m. and pressures from 0 to 350 p.s.i.

COOLANT — Pumps for handling cooling oils on machinery including pressure-releasing types.

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FUEL OIL — Pumps for fuel oil supply, for oil burners, for booster purposes on diesel engines.

Tuthill Pumps have a reputation for dependability proved by hundreds of thousands in the field.

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TUTHILL PUMPS

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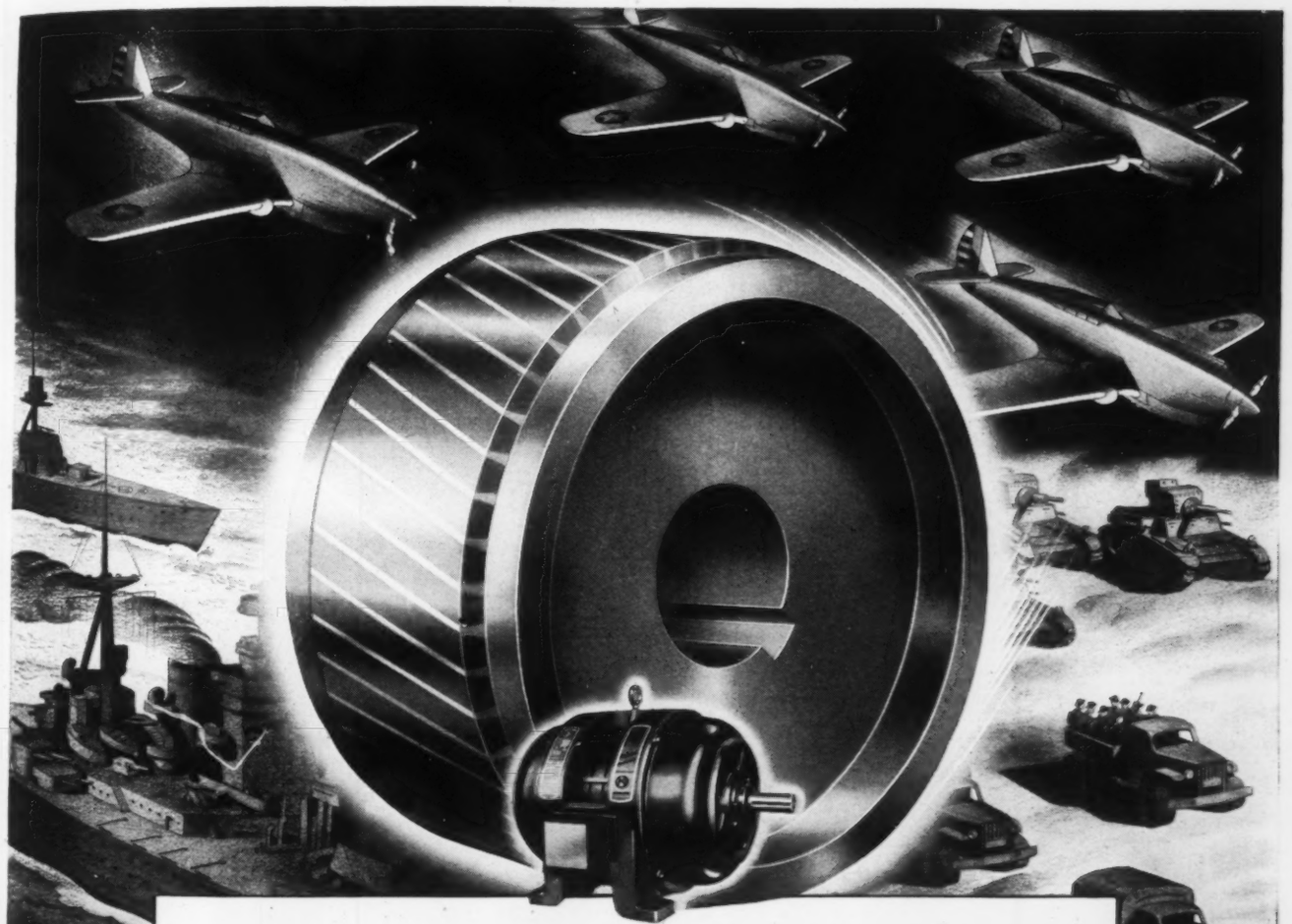
MEN *Of Machines*

FOR several months past Thomas J. Litle Jr. has been actively engaged in development of washing machines as a result of his recent appointment as engineering executive of Bendix Home Appliances Inc., South Bend, Ind. Previous to becoming connected with the Bendix organization, Mr. Litle had been directing engineering executive of both Lincoln and Marmon automobile companies, vice president of the Copeland Electric Refrigeration and Holley Carburetor Corporations. He has also been president of the Society of Automotive Engineers. In addition to these activities, Mr. Litle is also an inventor, having 366 inventions to his credit. At the moment, as in the case of many others, he is spending a good deal of his time on government activities at Washington and Dayton.

NEWLY appointed director of engineering, Joy Mfg. Co., Charles F. Ball has had long experience in developing automotive and special machines peculiar to construction work. This will be of assistance in designing caterpillar-mounted mechanical loaders and pneumatic-tired shuttle cars manufactured by the Joy company for handling coal underground.

A graduate in mechanical engineering of Uni-

(*Continued on Page* 108)



SPECIFY F-M MOTORS

with the Copperspun Rotor

for "ALL OUT" Production

There's no motor so capable of standing up to today's production tempo . . . of operating dependably under the most severe plugging and reversing service . . . as the Fairbanks-Morse Motor with one-piece rotor winding centrifugally cast of SOLID COPPER.

That's because copper has better electrical, thermal, and mechanical characteristics for motors than any other metal of which rotors are cast. You get the unique benefits of cast copper rotors in F-M Motors without extra cost . . . only F-M has succeeded in producing the *Copperspun* rotor.

Get the complete story of what F-M Motors with the patented features of Copperspun rotors can do for you in speeding production, reducing operating costs, and giving added years of trouble-free service. Write Fairbanks, Morse & Co., Dept. K-99, 600 S. Michigan Ave., Chicago, Ill. Branches and service stations throughout the United States and Canada.

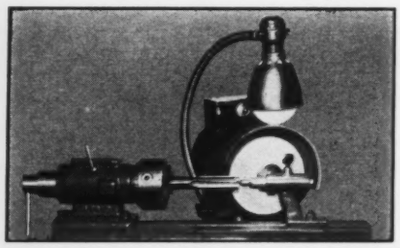
Copperspun
Patented

FAIRBANKS·MORSE MOTORS

DIESEL ENGINES ELECTRICAL MACHINERY RAILROAD EQUIPMENT WASHERS-IRONERS STOKERS
PUMPS FAIRBANKS SCALES WATER SYSTEMS FARM EQUIPMENT AIR CONDITIONERS

BETTER LIGHT

K. O. LEE
GRINDERS ARE
VIMCOLIGHTED



BIGGER OUTPUT

HALL MFG.
GRINDERS ARE
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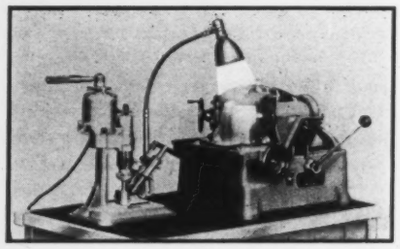
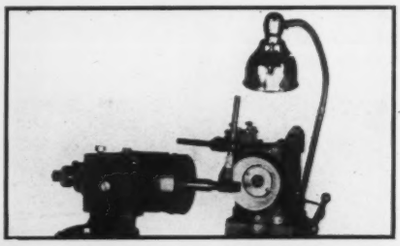


Vimcolight's high-intensity, *localized*, spot illumination . . . adjustable, low in cost . . . is now considered *indispensable* on many modern machines. Are *your* machines Vimcolighted?

COVEL
GRINDERS ARE
VIMCOLIGHTED



VIMCOLIGHT
VIMCO MANUFACTURING CO.
113 CHENANGO ST. BUFFALO, N. Y.

(*Continued from Page* 102)

versity of California, he became associated with Holt Mfg. Co. (now Caterpillar Tractor), and became chief designing engineer at its Peoria plant. He is credited with having developed a tractor attachment for trucks. Subsequently he became chief engineer of the construction equipment division of the Chain Belt Co., and continued in this position for sixteen years. Approximately 60 U. S. patents have been issued to him directly or as co-inventor covering tractor, traction and concrete mixing and pumping devices. He has made three trips to Europe in connection with concrete pump license agreements, and also, in connection with the Chain Belt concrete pump, has spent several months on the principal construction projects throughout the United States.

WITH a life ambition to become an aeronautical engineer, Hall L. Hibbard has more than realized his goal in his new appointment as vice president and chief engineer of Lockheed, one of the largest of the aircraft companies. For thirteen years, Mr. Hibbard lived with his missionary father in the Philippine Islands and then returned to the States to complete his education. He is a graduate of the College of Emporia, and Massachusetts Institute of Technology.

His first work in the aircraft industry was as a draftsman at the Stearman Aircraft Co., Wichita, Kans., in January, 1928. In three years he was advanced to project engineer, and later served for a time as consulting engineer with the Viking Flying Boat Co., of which Robert E. Goss was head. In 1931 Mr. Hibbard became chief engineer of the Stearman-Varney Co., and a year later came to Lockheed as assistant chief engineer. Largely as a result of work he has done on the famous Electra, he has been promoted to chief engineer and vice president.

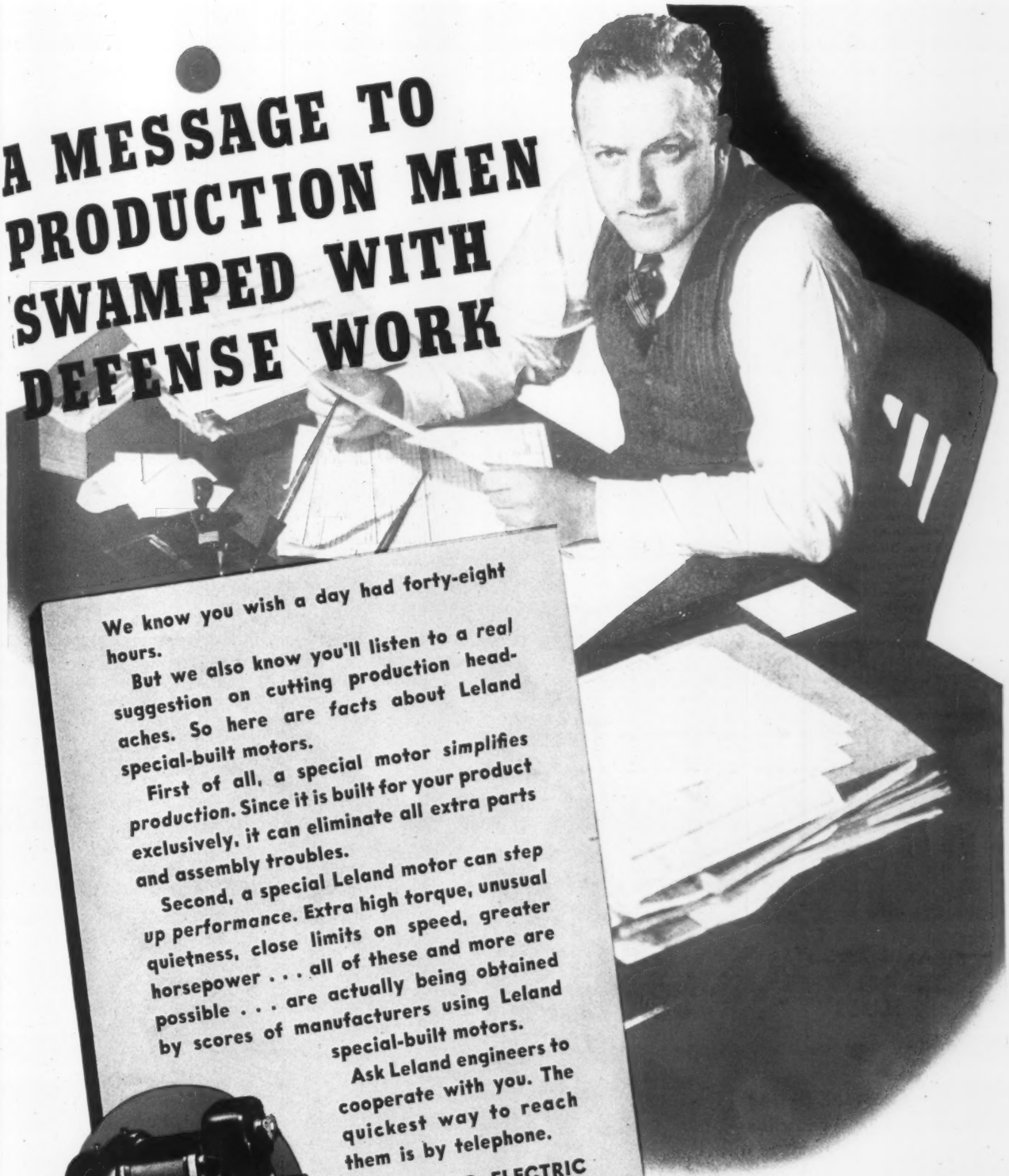
♦

LOUIS B. NEUMILLER who twenty-six years ago began his association with Caterpillar Tractor Co. in its engineering department, has been elected president of the company by the board of directors.

♦

G. K. VIALL, who has been connected with the Chain Belt Co. since 1921 in various capacities such as chief engineer and assistant to the president and works manager, has recently been appointed as head of a new division of research and

A MESSAGE TO PRODUCTION MEN SWAMPED WITH DEFENSE WORK



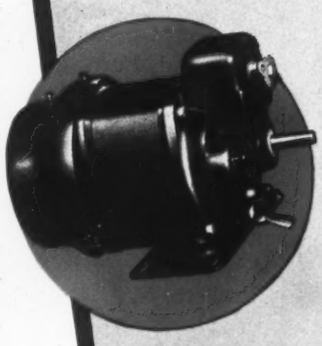
We know you wish a day had forty-eight hours.

But we also know you'll listen to a real suggestion on cutting production headaches. So here are facts about Leland special-built motors.

First of all, a special motor simplifies production. Since it is built for your product exclusively, it can eliminate all extra parts and assembly troubles.

Second, a special Leland motor can step up performance. Extra high torque, unusual quietness, close limits on speed, greater horsepower . . . all of these and more are possible . . . are actually being obtained by scores of manufacturers using Leland special-built motors.

Ask Leland engineers to cooperate with you. The quickest way to reach them is by telephone.



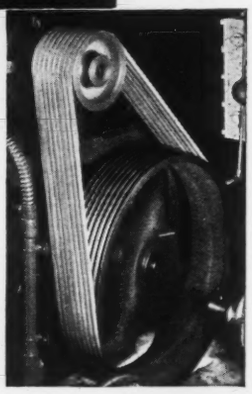
THE LELAND ELECTRIC COMPANY, Dayton, Ohio

Offices In All Principal Territories

LELAND
SPECIAL BUILT
MOTORS

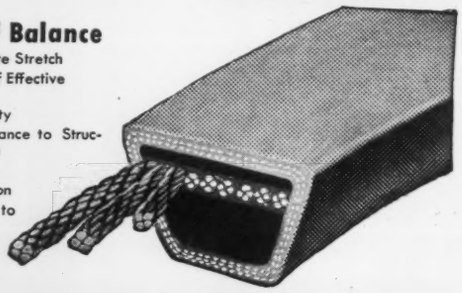
Condor V-BELTS
last longer

Back up the machines you build with low cost power and trouble free operation by using CONDOR V-Belts. The endless whipcord strength member in the neutral axis and completely floated in rubber—resists side wear, stretch and internal heat.



8 Points of Balance

1. Minimum Ultimate Stretch
2. Wide Margin of Effective Strength
3. Uniform Flexibility
4. Maximum Resistance to Structural Breakdown
5. Smooth Running
6. Maximum Traction
7. High Resistance to Side Wear
8. Correct Lateral Reenforcement



THE MANHATTAN RUBBER MFG. DIVISION
OF RAYBESTOS-MANHATTAN, INC.
Executive Offices and Factories, 141 Townsend St., Passaic, N. J.

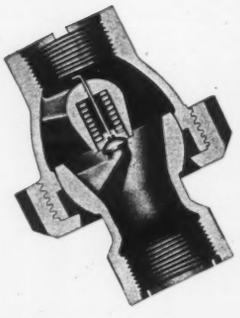
BARCO

STREAMLINED
FLEXIBLE BALL JOINTS

STEAM—AIR—GAS OIL AND OTHER FLUIDS

Stainless Steel Spring shrouded for protection against fluids, corrosion and erosion.

Spring pressure exactly centered against ball provides equal pressure of ball against gasket seat adjustment is automatic.



Spring Type Flexible Ball Joint 7X-8X Catalog 207

Barco Manufacturing Co.
1806 Winnemac Avenue, CHICAGO, ILL.
In Canada: The Holden Co., Ltd.

development, now being organized by the company. Mr. Viall is vice president in charge of the construction machinery division at the present time. He will continue fulfilling these duties, in addition to his new appointment.

♦

HERMAN G. KLEMM has been named chief engineer of the Glenn L. Martin Co., Baltimore. Formerly executive engineer of the organization, he will assume his new position at the company's new aircraft assembly plant at Omaha, Neb. Mr. Klemm has been in aircraft engineering for most of his career, having joined the Martin company at its Cleveland plant in 1927 as junior engineer. He was placed in charge of hull design when the company moved to Baltimore in 1929, then chief draftsman, and later, executive engineer.

♦

MAURICE N. LANDIS, who has served as chief metallurgist for LaSalle Steel Co., for ten years, has been appointed manager of metallurgical and research division. HENRY N. LANDIS has been appointed assistant manager of metallurgical engineering, under H. E. MACK, vice president in charge of metallurgical engineering.

♦

A. W. S. HERRINGTON, vice president, Marmon-Herrington Co. Inc., is a nominee for president of the Society of Automotive Engineers.

♦

DAVID ARNOTT, vice president and chief surveyor of the American Bureau of Shipping, New York, and second vice president of the American Welding Society, was awarded the Samuel Wylie Miller memorial medal "for conspicuous contributions to the art and science of welding". Award of the Lincoln Gold medal was made to ROBERT H. ABORN, member of the staff of the research laboratory of the United States Steel Corp., Kearney, N. J., for his paper "Metallurgical Changes at Welded Joints and the Weldability of Steels."

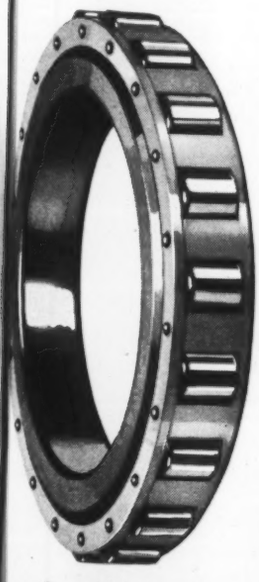
♦

H. E. CURLL, formerly chief engineer of Philadelphia Drying Machinery Co., and more recently vice president and chief engineer of Stoler & Curll Inc., has been appointed president and treasurer of Vulcan Corp. B. G. TARKINGTON, previously chief engineer of Bellevue Industrial Furnace Co., is chief engineer of the Vulcan Corp. which has acquired all patents, patterns, etc. of the furnace division of Philadelphia Drying Machinery Co.

♦

JOHN FLODIN, formerly senior mechanical engineer with the Bureau of Ships, Navy Department, Washington, recently became connected with Lidgerwood Mfg. Co., Elizabeth, N. J., in a design and development capacity. Mr. Flodin is known to readers of MACHINE DESIGN through the articles he has contributed to this journal, and it is understood that his work with the Lidgerwood company will be largely along the lines of marine equipment as were his particular responsibilities, both as to specifications, design and construction, while he was connected with the Navy Department.

Aircraft Bearings by Bower

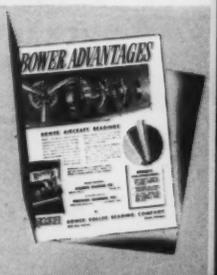


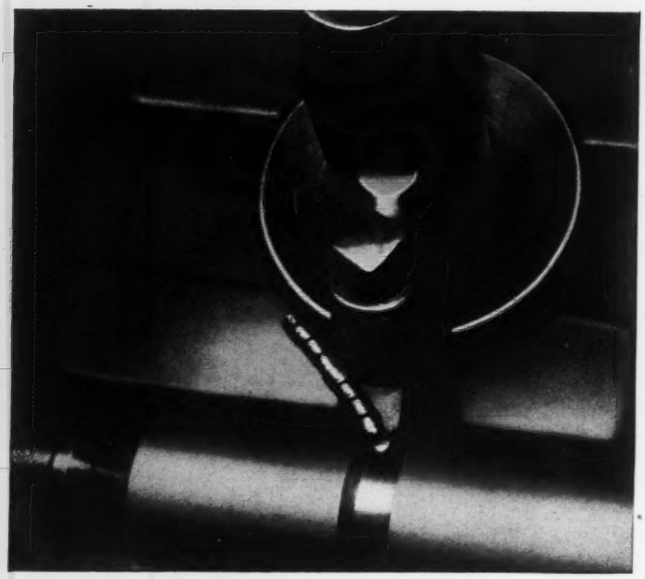
Propeller Shaft

BOWER
ROLLER BEARING CO.
Detroit, Michigan

Ask for it...

An interesting full color, 4-page folder featuring Bower advantages to national defense.



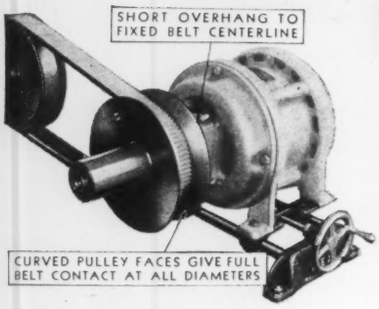


SPECIALISTS

● Choosing the right company for the right job is as important as any mechanical operation. We ARE specialists in designing and manufacturing machinery.

ENGINEERS
M. L. BAYARD & CO.
INCORPORATED
MACHINISTS
PHILADELPHIA

VARIABLE SPEED
IDEAL MOTOR PULLEYS



Wide V-Belt model illustrated available as a complete drive with Variable Speed Pulley, Adjustable Motor Base, Wide V-Belt and Driven Sheave. 3 to 1 speed ratio.

Give your products extra selling advantage, increase customer satisfaction.

SUPERIOR FEATURES:

- Inexpensive—Dependable
- Infinitely variable speed over wide ratio.
- Speed changed while running.
- Simple design—modern construction.
- Available in V-Belt and Wide V-Belt Types.
- Sizes up to 8 H.P.

OUR ENGINEERS AT YOUR SERVICE

Write for information on the complete line of IDEAL Variable Speed Pulleys, "Select-O-Speed" Transmission and "Automatic" Motor Bases.

TRANSMISSION DIVISION
IDEAL COMMUTATOR DRESSER COMPANY
1059 Park Avenue Sycamore, Illinois
"Sales Offices in All Principal Cities"
In Canada: Irving Smith, Ltd., Montreal, Quebec.

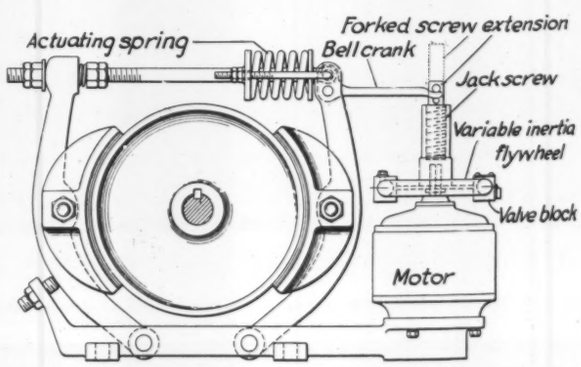
Noteworthy PATENTS

Flywheel Inertia Adjustable

TIMING devices designed to control the operation of a motor or other prime movers by limiting the number of revolutions in a forward or reverse direction require means for controlling the rate of acceleration and deceleration. In a patent assigned to Cutler-Hammer Inc., this is accomplished by an auxiliary electric motor controlled by a variable inertia flywheel operating a pair of brake shoes which coact with a drum on the prime mover shaft.

An actuating spring on the connecting link between the two arms on which the brake shoes are mounted tends always to engage the brake shoes with the drum. This action is accomplished by mounting the spring in a retaining yoke pinned to the hinge point junction of the brake-shoe arm and connecting link. Engaging also with this pinned joint is one arm of a bell crank lever, the other arm of which is constrained in the forked extension of a jackscrew operated by a nut integral with the auxiliary motor shaft.

When the motor is energized, the jackscrew is raised until the brake is released. The motor then remains stalled until the brake is to be set. At this



Check valve controls flow of mercury through toroidal ring flywheel during acceleration and deceleration

time, the motor is de-energized and the thrust of the actuating spring tends to rotate the bell crank lever clockwise exerting downward thrust on the jackscrew which rotates the motor armature idly in the reverse direction.

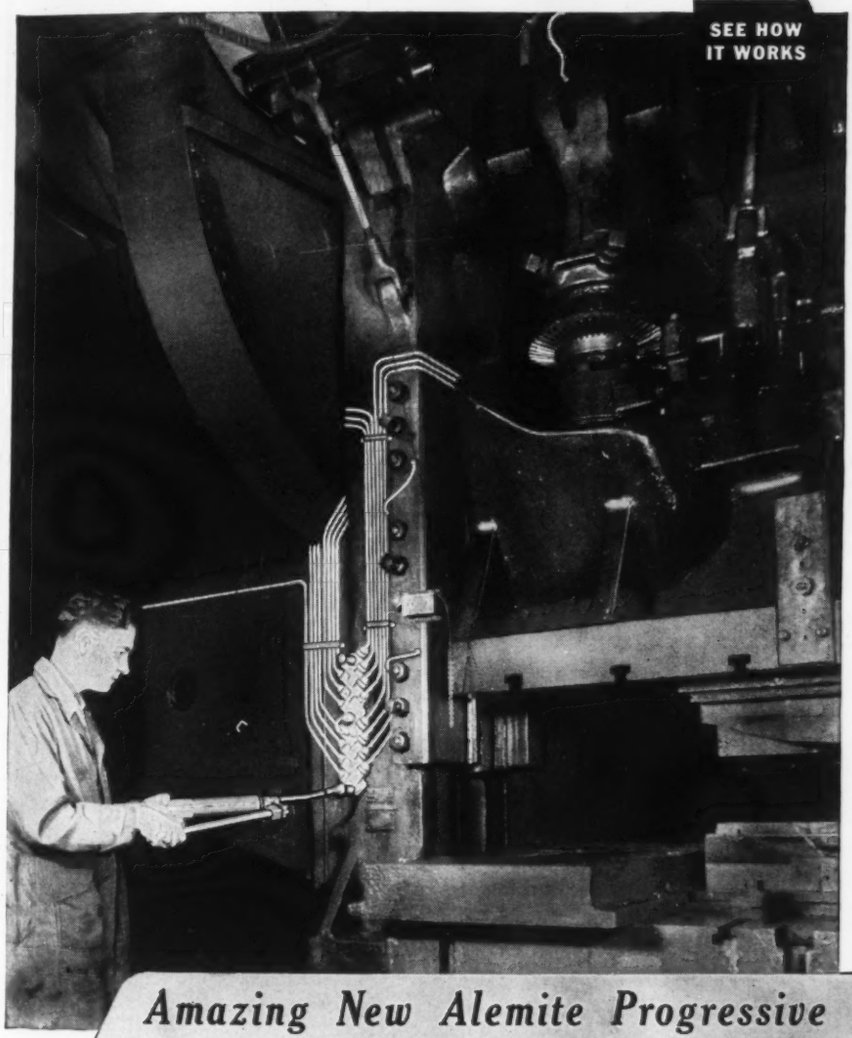
To provide the adjustable inertia feature, a variable-inertia flywheel is used. This flywheel is a

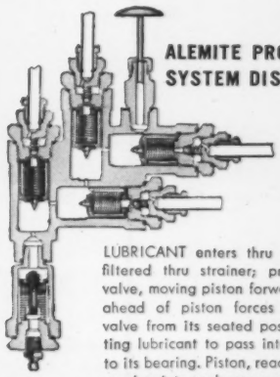
(Continued on Page 118)

NEW CENTRALIZED LUBRICATING SYSTEM

Ends "Time Out" for Lubrication

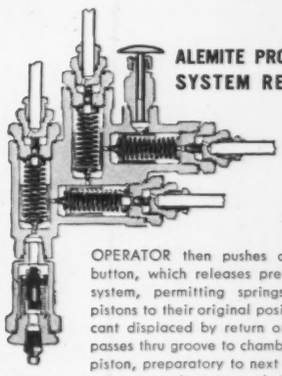
Serves all bearings from one location with one "shot"





ALEMITE PROGRESSIVE SYSTEM DISCHARGING

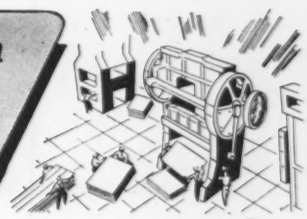
LUBRICANT enters thru fitting and is filtered thru strainer; pressure forces valve, moving piston forward. Lubricant ahead of piston forces open second valve from its seated position, permitting lubricant to pass into line and on to its bearing. Piston, reaching most forward point, seals passage and permits grease under pressure to operate next valve in series. Process is then repeated. As last piston clears indicator port, lubricant enters under indicator shaft and moves it to outward position, signaling operator that all bearings have received their predetermined charge of lubricant and the job is done.



ALEMITE PROGRESSIVE SYSTEM RELOADING

OPERATOR then pushes down signal button, which releases pressure within system, permitting springs to return pistons to their original positions. Lubricant displaced by return of piston bypasses thru groove to chamber ahead of piston, preparatory to next lubrication. In this illustration the original position of the system is shown, with self-aligning valves held seated against intake ports. System is not under pressure. It is loaded and ready for the next cycle.

Amazing New Alemite Progressive System Delivers Predetermined Quantity of Grease to Each Bearing . . . Signals When Finished



ALL INDUSTRY is feeling the emergency demand for stepped-up production. Machines and men are being taxed to the limits of endurance. Under such conditions it becomes *vitally important* to make every man-hour, every machine-hour *show maximum results* in terms of finished products.

The new Alemite Progressive Lubrication System contributes to this end. It permits lubrication while machinery is in operation—*saving machine-hours and man-hours and increasing output.* It speeds lubrication. It promotes safety by bringing remote bearings into easy reach.

Accurate, positive, dependable lubrication is assured with this system. Every bearing gets a predetermined quantity of grease. An automatic device signals the operator when the job is done. Write today for complete details of this time-saving, money-saving lubrication method!

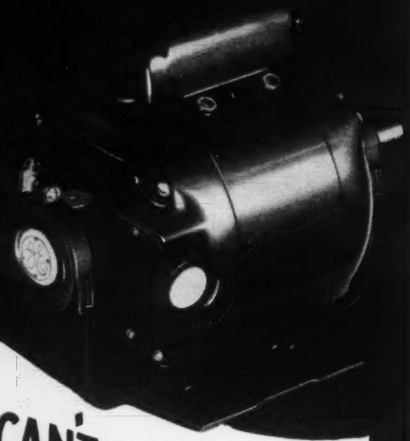
Ask Anyone in Industry!

ALEMITE
REG. U. S. PAT. OFF.
Industrial LUBRICATION
1804 Diversey Parkway, Chicago, Illinois • Belleville, Ontario

Another Product of
STEWART WARNER

FOR HIGH TORQUE, LOW MAINTENANCE AND ALL-ROUND PERFORMANCE

These quiet motors are available in ratings from 1/8-hp through 3/4-hp in all standard voltages and frequencies.



YOU CAN'T BEAT THIS G-E CAPACITOR-MOTOR

WHEN YOU NEED A MOTOR THAT

. . . . . has high torque, is quiet running, and has constant speed.

. . . . . is especially suitable for such machines as water pumps, compressors, beverage coolers, room coolers, stokers, unit heaters, refrigerating equipment, and many other applications.

. . . . . does not interfere with radio reception.

. . . . . requires no attention except for infrequent lubrication.

. . . . . will stay on the job day in, day out.

CONSIDER THE GENERAL ELECTRIC CAPACITOR-MOTOR

You can rely on it to give the sort of motor performance that you want.

Our engineers will be glad to work with you in solving your motor problems. For this service, contact the nearest G-E sales office, or write General Electric, Schenectady, N. Y.

And remember that there is a complete line of G-E fractional-hp motors.

GENERAL ELECTRIC

700-46-8260

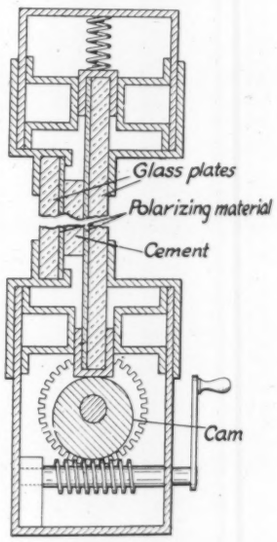
(*Continued from Page* 112)

toroidal ring formed by two semicircular sections of tube, the ends of which are welded together in two blocks. The ring is filled with a heavy fluid such as mercury. One of the blocks, shown as the valve block in the illustration, contains a spring-restrained check valve disk which abuts against the end of one of the semicircular tubes. The valve disk spring thrust is adjustable.

When the motor is energized, the restriction to the flow of mercury in the flywheel provided by the check valve increases the inertia of the system; the greater the restriction, the higher the inertia. Obviously the valve arrangement may be so designed that the check valve under the influence of fluid pressure may open freely for rotation in one direction and close completely for rotation in the other. Thus minimum and maximum inertia may be attained for opposite rotational directions.

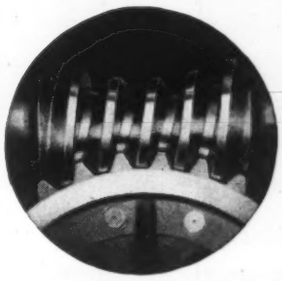
Varies Transmission of Light

INTERFERENCE effect of two transparent polarizing elements has often been considered as a possibility for the elimination of glare through automobile windshields and other windows. Assigned to the Polaroid Corp., a patent has been issued disclosing a practical means of achieving this end. Two such sheets of polarizing material, their axes of transmission at a relative angle of 90 degrees are each bonded to one of two sheets of glass or other protective transparent material. The polarizing sheets are then bonded together by a transparent elastic cement such as vinylite.



Imposing shear stress on elastic, transparent plastic bond induces lamination to act as a half-wave plate

One of the laminated glass and polarizing material elements is rigidly fixed in a frame, the other is arranged to be displaced slightly in one direction by means of appropriate adjustments. One mechanism for effecting this adjustment is shown in the illustration as an eccentric cam driven by a worm and wheel. In the illustrated non-displaced position no light is passed through the system. When, however, the adjustable plate



"*When* DEFENSE PRODUCTION STOPS"*

**No. 1 of a series of advertisements designed to help industry prepare for the day "When Defense Production Stops."*

YOUR ORGANIZATION is probably in the same situation we are in today—with manufacturing facilities devoted "all-out" to production for defense—with vital defense needs precluding production for non-defense industry.

One of these days, however, defense production will suddenly cease. It is our belief that the time to start preparing for that inevitable moment is not tomorrow, but today—with designs of new products, new equipment, new models.

Fortunately, as the defense job gets more and more into the mass production phase, pressure on your design engineering department, as well as our own, is being relieved.

TO ASSIST COMPANIES NOW ENGAGED IN, OR PLANNING TO START, NEW DESIGNS—TO PUT ON THE SHELF UNTIL DEFENSE PRODUCTION STOPS—OUR ENGINEERING DEPARTMENT WILL DESIGN THE REQUIRED CONE-DRIVE GEARING WITHOUT CHARGE OR OBLIGATION.

You will find that double-enveloping Cone-Drive gearing will improve the design, lower the cost, and improve operation if only because of its greater load carrying capacity, greater compactness and longer life.

We will be glad to send you a manual on Cone-Drive Gearing. Ask for No. CW-41A (For executives); CW-41 (For design engineers).

CONE-DRIVE DIVISION
Michigan Tool Company **Detroit, U. S. A.**

MUST YOUR GASKETS RESIST OIL, GASOLINE or CHEMICALS?

• Then investigate Fel-Pro LIGNOFLEX, a synthetic gasket material practically unaffected by petroleum products as well as many chemicals and solvents including Freon, Lacquer Thinners, etc. LIGNOFLEX has many other valuable qualities, permanent resiliency, edges as well as surfaces sealed, exceptional resistance to deterioration; available in various thicknesses and hardnesses to meet your special gasket requirements.

FEL-PRO LIGNOFLEX

SEND FOR FREE SAMPLE BOOK

• Get Free Samples of LIGNOFLEX; also Fel-Pro's FREE Engineer's Sample Book containing thirty-six Special Materials that will help solve your gasket and packing problems. Full specifications and data given on each material. Suggestions for all industrial applications. Ends guesswork about gaskets. Write today for your FREE copy of this valuable Fel-Pro Sample Book, to Felt Products Mfg. Co., 1517 W. Carroll Ave., Chicago, Ill.

FEL-PRO Gaskets
PUMP PACKING
GREASE RETAINERS

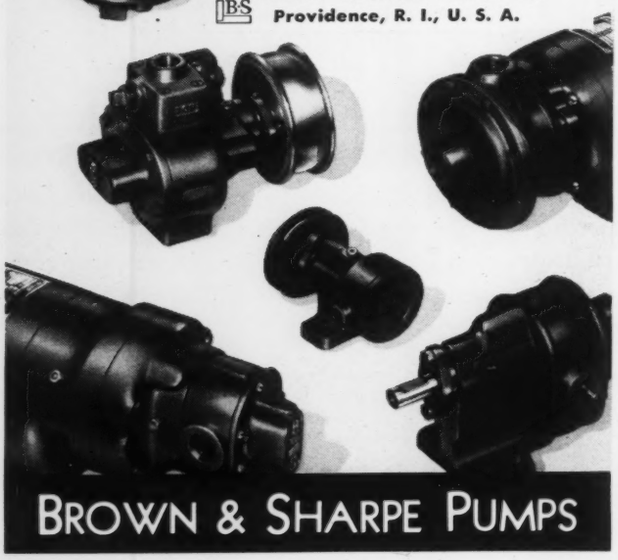
When you have an unusually difficult gasket problem, call on Fel-Pro's Consultation Service. Write us in detail. Our specially experienced engineers will help you find the answer; no obligation.

Help your Machines Meet Today's Needs—with Reliable BROWN & SHARPE PUMPS

Geared—Vane—Centrifugal

Write for Catalog showing a wide range of sizes for various applications.

BROWN & SHARPE MFG. CO.
Providence, R. I., U. S. A.



BROWN & SHARPE PUMPS

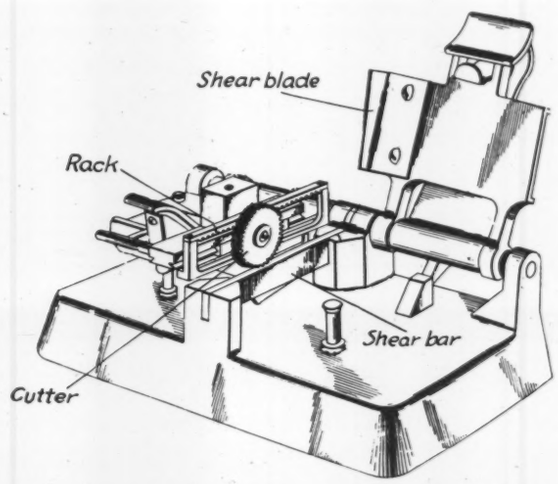
is elevated, the elastic cement bond is subjected to shear and hence acts as a half-wave retardation element. The transmitted light gradually increases with the shear stress imposed on the cement until such a time as the light transmitted by one polarizing element has its vibration direction rotated through 90 degrees at which time all of the light will also be transmitted by the second element.

Rack and Pinion Drives Cutter

ELIMINATION of the risk of damaging the cellulose base of a film while removing the surface emulsion preparatary to splicing a film is achieved by a splicer the patent for which is assigned to Warner Bros. Pictures Inc. by Roy C. McClay.

A scraper, resembling an end-mill cutter with helically formed teeth is utilized. A pinion gear mounted on the cutter shaft engages with a transverse rack mounted on the frame of the machine. As the cutter is drawn across the film it is rotated by the rack and pinion drive, providing a scraping action. Since the cutter teeth are helical any curling tendency of the end of the film is ironed out before the actual scraping action occurs, thereby eliminating the risk of damage.

Edge support for the section of the film being scraped is provided by a shear bar which coacts



Helical teeth on end-mill cutter prevent film damage in scraping for splicing

with a shear blade to sever the film when the shear blade carriage is rotated downward about its pivot shaft. Thus the width of the scraped surface is controlled by the width of the cutter and scraping may be accomplished either before or after the shear operation.

Single-edged blades or knives for scraping the emulsion have the disadvantage of being subjected to appreciable wear because all the work is done by a single cutting surface. In this slicer this objection is overcome by the helical-toothed end-mill cutter. Smoother action is also obtained by the

A New Principle OF COIL INSULATION

FORMEX wire represents a basic improvement, an entirely new principle of coil insulation; that is, we put the insulation where it belongs—one covering, on the wire itself.

The Old Way

Separate wraps, treatments, bonding and multiple layers to do separate jobs—that was the old concept of insulation. The initial insulation, generally enamel, was satisfactory electrically but lacked physical strength. When other layers or treatments were added, they frequently detracted from the properties of the primary insulation or were themselves weak in some respect. Bonding varnish sometimes attacked the enamel film, weakening its electrical strength or resistance. And if the enamel film were made resistant to the solvents in good treating varnish, then it lost the property of good resistance to heat and tension. Such are the common difficulties in following the old concept of coil insulation.

NOW YOU CAN...

- ✓ SIMPLIFY VARNISH TREATMENT
- ✓ SAVE SPACE
- ✓ WIND COILS EASILY
- ✓ GET MORE FEET OF WIRE PER POUND

These are fundamental improvements and advantages not available before in one insulation.

Use **FORMEX** MAGNET WIRE A PRODUCT OF G-E RESEARCH

THE WIRE FOR ALL-ROUND STRENGTH

Formex wire provides the best all-round electrical and physical properties. It is easy to install and is long-lasting. To any manufacturer who is considering the use of Formex magnet wire, we offer the advisory service of our magnet wire specialists and engineers. Just write the nearest G-E office, or General Electric Company, Schenectady, N. Y.

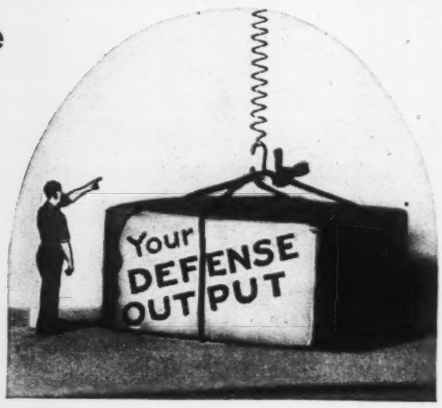
Plenty of Insulation There!

This clipping refers to Formex wire: The item appeared in a recent article in "The American Magazine" and "Reader's Digest." It was written by Dr. W. D. Coolidge, Director of the G-E Research Laboratory.

Recently a customer returned an electric motor because, he reproached us, "This is wound with bare wire." We had a hard time convincing him that the "bare" wire was safely insulated. Nor could we blame him for being skeptical. For 30 years there had been almost no innovations in insulating wire; we had to use cumbersome cotton or paper, varnishes and enamels were easily cracked. Only lately had we learned of an insulating substance, made from coal and lime, that we could so apply to a wire that it seemed to become a very part of it. Wire coated with it could be smashed flat or twisted thousands of times; still the coating was intact. Already this magic coating is spreading through industry.

GENERAL ELECTRIC

Is it at the mercy of a slender spring ?



DON'T let your Defense output lag for lack of a spring or a screw machine product. If your source of supply is inadequate, our long experience in making such parts, in quantity, and to extreme precision standards when desired, is yours at reasonable cost.

Tell us what you need to smooth out your Defense or civilian production. We may be able to help you to get going at schedule speed.

PECK SPRINGS
AND SCREW MACHINE PARTS
The Peck Spring Co. **10 Wells St., Plainville, Conn.**

Gear Specialties

SPURS—SPIRALS—BEVELS—WORM GEARING
(14 to 96 D.P.)

With considerable experience and exceptional facilities for the manufacture of high precision Small Gears, our manufacturing capacity is now heavily burdened with National Defense work, and we naturally feel pardonable pride in the importance and quality of our contributions to the Program.

While this very essential work takes precedence, we are keenly conscious of our *duty* to *established* customers; their needs must command our continued earnest efforts. Under such circumstances, we hope new inquirers will understand our inability to give their wants the consideration they would ordinarily receive.

Gear Specialties
MANUFACTURERS
CHICAGO

2670 W. MEDILL AVE. **Ph. HUM. 3482**

positive elimination of any tendency to "chatter" which might otherwise result in uneven removal of the emulsion.

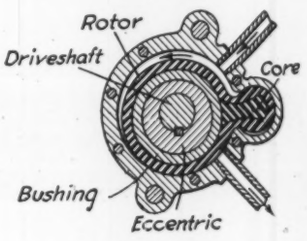
In applying pressure to the lapped ends of the film which have been previously cemented the pressure pads are applied over an area less than the area of overlap. Therefore, any cement which tends to exude from between the sections of the film under the pressure pad does not collect outside of the lapped portions. This method of applying pressure has the further advantage of providing a fillet at both ends of the lapped joint which materially reduces the likelihood of film breakage.

Rubber Eliminates Slippage

EFFICIENT and economical variation of the rotary-eccentric positive-displacement pump is disclosed in a patent assigned to the Detroit Harvester Co. Resilience of rubber or synthetic rubber materials is utilized to eliminate all but one metal-to-metal bearing part in the pump chamber.

Concentric with the pump housing, a driveshaft has keyed to it an eccentric disk. Rotation of the shaft thus produces rotation of the eccentric within a plain bushing. The outer surface of the bushing has, molded to it, a rubber or rubber-like material.

Serving the twofold purpose of separating the inlet and outlet chambers as well as preventing



Rubber or synthetic rubber eliminates all but one metal-to-metal bearing surface in fluid pump

rotor rotation relative to the housing, the rotor is molded with an enlarged cylindrical portion on one side which is accommodated by a chamber in the housing. In order that the soft rubber rotor should not deform excessively under the torque load of the pump, a hard rubber core is molded within the enlarged portion. Since the rotor may be made somewhat oversize, extremely intimate contact between the rubber and the housing is maintained, effectively eliminating all but a nominal amount of face leakage.

Since the metallic bushing to which the resilient rotor is bonded is free to rotate in relation to the eccentric, no sliding contact between the rotor and the pump housing is experienced. The rubber core, constrained in the housing, serves to prevent this rotation. Hence pumping action is achieved by progressive differential elements of the cylindrical surface of the rotor coming into contact with the housing bore.

No Time Out for Speed Changes

● Ability to change speeds quickly and accurately is contributing importantly to National Defense in thousands of manufacturing plants where machines are equipped with REEVES Variable Speed Control.

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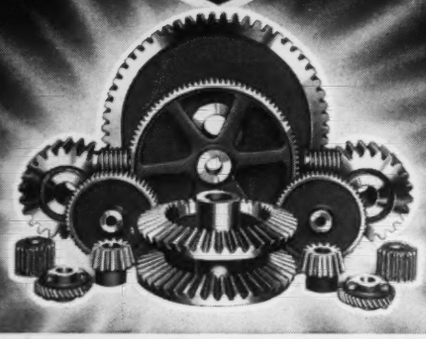

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(*Continued from Page* 46)

utilized in the differential adjusting nut, *Fig.* 6. Elliptic holes or slots are punched in the blank so that their long axes approximately coincide with tangents to a circle drawn about midway of the material constituting the corner radius. In the drawing operation, these holes are deformed so

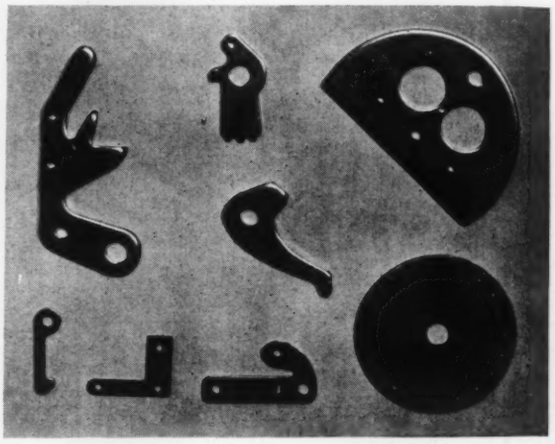

Fig. 7—Holes punched in these machine parts are much smaller in diameter than the thickness of metal stock, have no taper and possess a burnished finish

that they are sufficiently round to accommodate a spanner wrench.

Flow of metal in the corner of this part during the draw, as well as in other parts, such as that in *Fig.* 2, results in a thinning of the stock. On the tension side of the bend the metal is drawn out; on the compression side it is squeezed out laterally, producing edge irregularities. The narrower the strip being bent in relation to its thickness, the more pronounced this distortion becomes. In wider strip, since the metal in the center has no place to go, irregularities at the edge are less pronounced and there is less reduction in stock thickness.

Flatness Produced by Restriking

In the nut illustrated in *Fig.* 6 the objectionable hole edge deformation is overcome in a final restriking operation which results in an essentially flat top for the part.

Being a sealing surface, the bottom edge of this nut is specified to be flat within close tolerances. Also, because a thread is to be cut on the outer cylindrical surface requires that this part be completed by a machining operation. In many cases a careful analysis of design may disclose that maximum economy may be obtained by following

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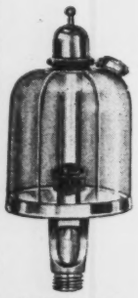

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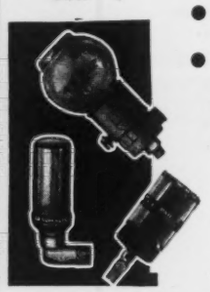

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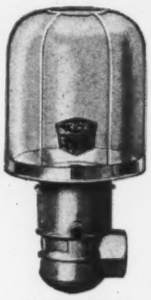

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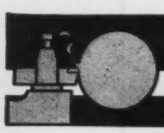

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the stamping operations by one or more supplementary fabricating methods such as welding, machining or combining with forgings or castings.

Apropos of a previous statement that all good rules have their exceptions, *Fig.* 7 is included. The several stamped steel parts therein illustrated have punched holes which are, in diameter, much less than the stock thickness. These holes are made with special punches combining a burnishing action. The punches are fitted with telescoping or intermeshing guides which make possible greatly reduced clearance with the die. This fact combined with the burnishing action makes possible the punching of small holes without taper or breakaway to tolerances as close as .0002-inch. Furthermore, holes may be punched in round stock or at an angle to the surface of flat stock, not ordinarily possible with more conventional tools.

With these advantages, holes may be punched in steel in thicknesses of 1½ diameters; in brass, of 2½ diameters; and in copper or aluminum, up to 4 diameters. Reasonable tool life is experienced which, considering the expensive machining eliminated, may result in definite economy.

MACHINE DESIGN acknowledges the valuable cooperation of the following companies in the preparation of this article: Geometric Stampings Co. Figs. 1, 3, 5 and 6; Globe Machine and Stampings Co. Figs. 2 and 4; Durable Punch and Die Co. Fig. 7.

Utilizing Porcelain Enamel

(*Continued from Page* 65)

stant effort of the enamel technologist is to produce an enamel of superior capacity or covering power so that a given appearance or degree or reflectance can be produced with a relatively thin coat. The relation between thickness of cover coat and resistance to bending is illustrated in TABLE III. Thickness refers to the actual thickness of the fired cover coat of enamel. "Deflection" indicates the deflection of the test piece causing failure in the bending test mentioned in Part I.[§]

Similar data are given in TABLE III to indicate the relation between the thickness of cover coat and reflectance. The enamel termed "opaque" represents a good grade of enamel typical of practice a few years ago, while the one designated as "super-opaque" indicates progress in the development of greater opacity.

A reflectance of 75 per cent is a common specification. An analysis of the foregoing data is made in *Fig.* 4. To obtain this reflectance with the opaque enamel, a thickness of approximately .012-inch is required, while it may be obtained by a thickness of .008-inch with the super-opaque. Additional thickness contributes increasingly less reflectance but rapidly decreases the deflection causing failure.

Thickness as actually measured by a magnetic gage includes the thin layer of ground coat between

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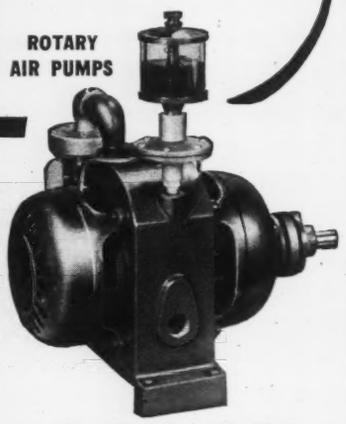

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the metal and the cover coat. Hence, requirements for maximum thickness should take the ground coat into consideration. Early specifications allowed for total enamel thickness on the order of .025 to .030-inch. With improvements in enamels and processing methods, the figure is often put at .020-inch and some shops are rejecting a total thickness of over .015-inch.

A final point that may be of use in connection with sheet metal enamels, and one that is definitely related to thickness of enamel, is the color matching of unit parts. From the data presented, it is obvious that differences in reflectance go with variations of enamel thickness. Certain tolerances in thickness and reflectance must be allowed for both white and colored enamels. The skillful use of brushing or, in some cases, metal-joint cover strips will go far in decreasing the effect of slight differences in color between adjacent panels and in affording pleasing contrasts.

Correct design of parts to be porcelain enameled is essential if freedom from enamel defects is to be secured. To effect this goal, the following points should be kept in mind:

1. Sheet metal of the proper gage and working properties should be selected
2. Shapes should be as simple as possible
3. Sizes should be proportionate, avoiding long, narrow shapes
4. Unsymmetrical embosses and offsets should be avoided
5. Flanges should be used for strength where necessary, with minimum depths of ⅜-inch (½-inch is safer)
6. Flanges should be welded at corners
7. Cutouts in flanges should be avoided
8. Cutouts in body should be avoided wherever possible
9. Holes for handling during firing should be provided and spaced to give uniform weight distribution (for continuous furnaces)
10. Double thickness of metal should be kept at a minimum
11. Large angle reinforcements welded to back of parts should be avoided.

Observance of these suggestions will go a long way toward assuring properly designed parts for the maximum utilization of porcelain enamel. Further, many of the ills attributed to enamel could be cured readily through redesign of parts, resulting in simplification of processing and assembly as well as both reducing costs and obtaining more serviceable units.

Theory of Elasticity in Practical Design

(*Continued from Page* 71)

These stresses across a section of the disk are plotted in *Fig.* 101. Both S_ρ and S_θ are always tension. The maximum Q stress will therefore be in the plane perpendicular to the plane of the disk and, since the principal stress in the third direction is zero, it will be equal to S_θ.

Extending these equations to the hollow disk of

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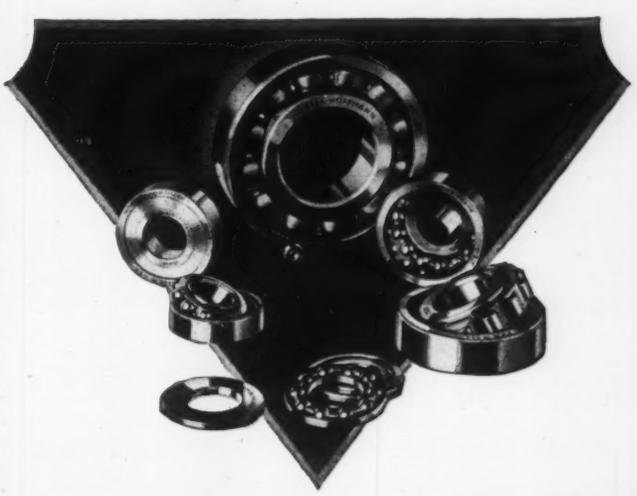

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Fig. 102, when ρ equals r_1 and r_2 respectively at the inner and outer boundaries, S_ρ will be equal to zero, from which

$$A = \frac{3+\lambda}{8} m\omega^2 (r_1^2 + r_2^2)$$

$$B = -\frac{3+\lambda}{8} m\omega^2 r_1^2 r_2^2$$

Substituting these values of the constants into Equations 174 and 175

$$S_\rho = \frac{3+\lambda}{8} m\omega^2 \left[r_1^2 + r_2^2 - \frac{r_1^2 r_2^2}{\rho^2} - \rho^2 \right] \quad (179)$$

$$S_\theta = \frac{3+\lambda}{8} m\omega^2 \left[r_1^2 + r_2^2 + \frac{r_1^2 r_2^2}{\rho^2} - \frac{1+3\lambda}{3+\lambda} \rho^2 \right] \quad (180)$$

and the stress difference $Q_{\rho\theta}$ becomes

$$Q_{\rho\theta} = \frac{3+\lambda}{4} m\omega^2 \left[\frac{r_1^2 r_2^2}{\rho^2} + \frac{1-\lambda}{3+\lambda} \rho^2 \right] \quad (181)$$

In *Fig.* 104, these stresses across a section of the disk are plotted. S_ρ and S_θ are again always tension and therefore the Q stress in the third direction will be the maximum and will be given by S_θ.

At the boundary r_1, as r_1 approaches zero, S_θ approaches twice its value at the center of a solid disk. In other words "a hole of 'zero' diameter doubles the stress." This same phenomenon was observed in the case of solid and hollow cylinders under radial surface loads, discussed in the May issue.

R. P. M. Makes Equations More Useful

As r_1 is increased while maintaining r_2, the condition of a thin hoop is approached, for which

$$r_1 = \rho = r_2 = r$$

approximately, where r is the mean radius. Substituting in Equation 180 gives

$$S_\theta = m\omega^2 r^2$$

which is the usual expression for the tangential stress in a thin rotating hoop.

The equations for the stress in rotating disks will be more useful if expressed in terms of "r.p.m." and pounds per cubic inch for density. Making this transformation, and using the average value of λ of .30, gives for the tensile stress at the center of the solid disk, from Equation 177.

$$S_0 = 11.72\, r^2 (\text{rpm})^2 (\text{density}) 10^{-6} \quad (182)$$

and at the boundary

$$S_r = .42 S_0 \quad (183)$$

Variations in the value of λ, in the range from .25

(*Continued on Page* 136)

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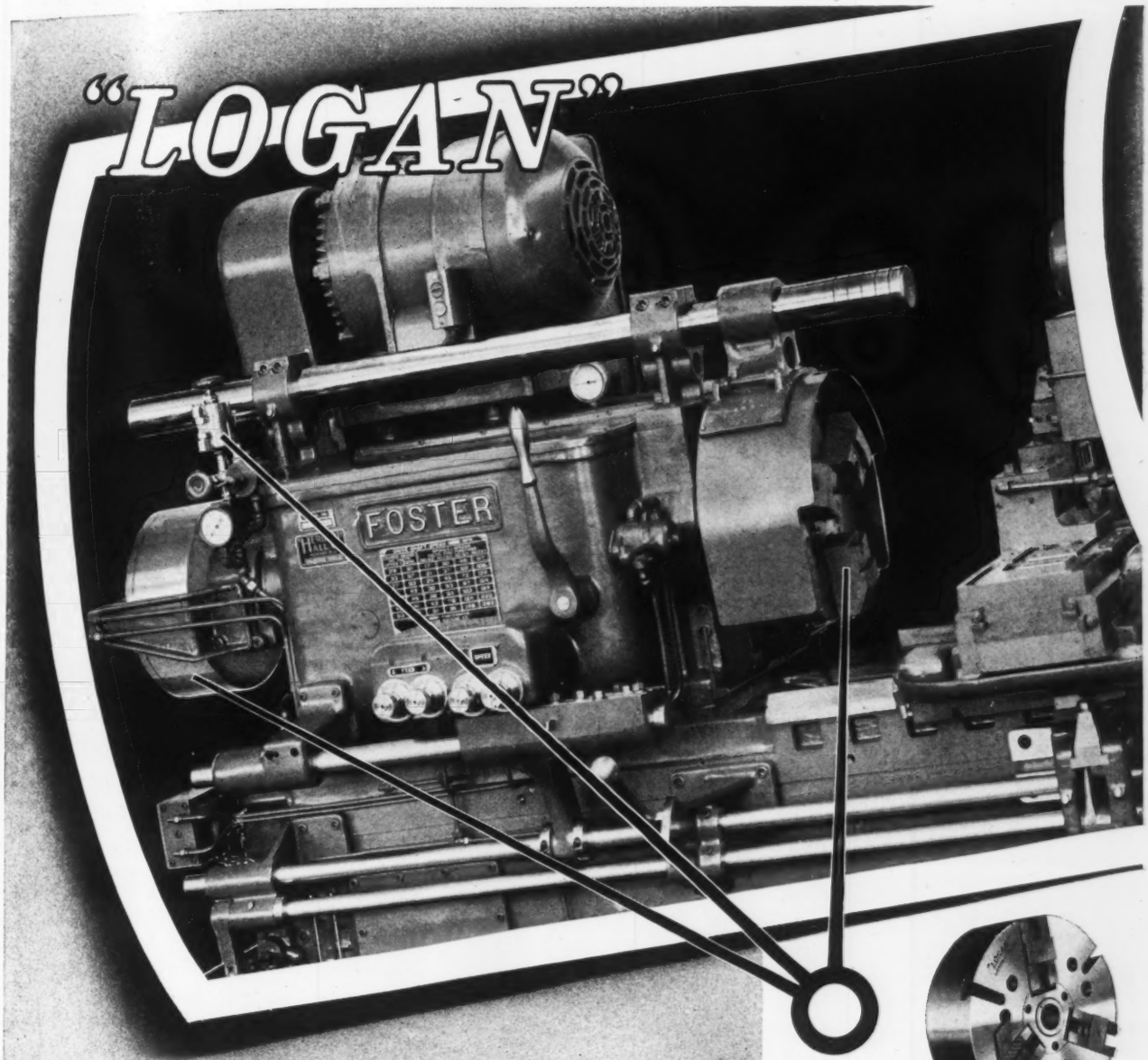

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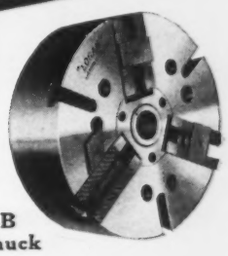
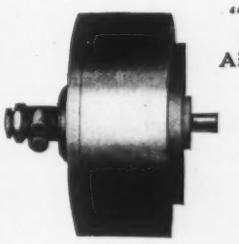


Model 350-B
"LOGAN" Chuck



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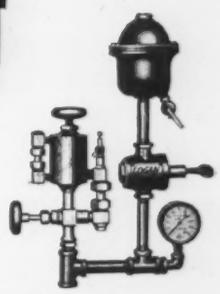

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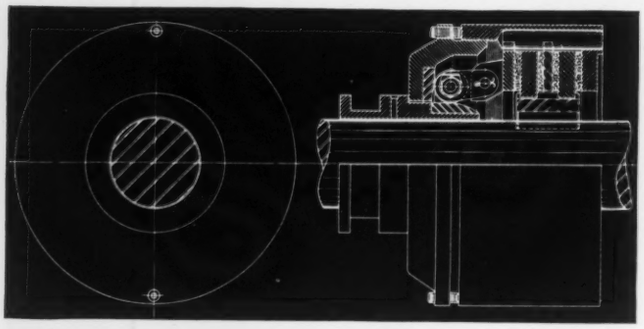

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(*Continued from Page* 130)

to .35, will have but very small effect on these values.

In *Fig.* 103 is a nomographic chart for the determination of S_0. For reading, the chart is followed through in order of column numbers beginning with Column 3 (Columns 1 and 2 are for hollow disks and will be explained later). In the example shown, on Column 3 the radius is 10 inches. On Column 4, the r.p.m. is 8000. The intersection of the line from these two points with Column 5 gives the "turning point." On Column 6 the density is .26 pounds per cubic inch and the line from this point through the turning point gives $S_0 = 19{,}500$ pounds per square inch on Column 7.

Maximum Stress Is at Inner Boundary

The maximum stress in the hollow disk is at the inner boundary from which, using Equation in 180,

$$S_{r_1} = \frac{3+\lambda}{8} m\omega^2 \left[2 \left(r_2^2 + \frac{1-\lambda}{3+\lambda} r_1^2 \right) \right]$$

If substitution is made in this equation of

$$r = \sqrt{2 \left(r_2^2 + \frac{1-\lambda}{3+\lambda} r_1^2 \right)} \qquad (184)$$

the equation reduces to

$$S_{r_1} = \frac{3+\lambda}{3} m\omega^2 r^2$$

which is the same as that obtained from Equation 177 for the stress at the center of a solid disk of radius r. It is apparent then, that the solution of the hollow disk resolves itself into finding the radius of a solid disk that will give the same stress at its center, and then using the chart of *Fig.* 103. This equivalent radius is obtained from Equation 184.

Photoelastic Analysis Is Difficult

Columns 1, 2 and 3 of *Fig.* 103 form a chart for solving Equation 184. In the example shown, a 6.94 inch radius disk with a 2.78 inch radius hole is used for which r_1/r_2 is .4. From $r_1/r_2 = .4$ on Column 1, the line from this point through 6.94 on Column 2 gives 10 inches on Column 3 as the equivalent radius of solid disk. If the density and rotation is the same as in the previous example, the solution is already worked out on the chart, from which the tangential stress at the inner boundary is 19,500 square inches.

Since the stress varies with λ, an exact photoelastic analysis is not possible unless the material of the actual part has the same constant as the model material. However, the error in ignoring the change in λ is not large.

Photoelastic analysis of a rotating disk is a difficult task but is not impossible. Dr. Hetenyi of Westinghouse Electric has made some very inter-

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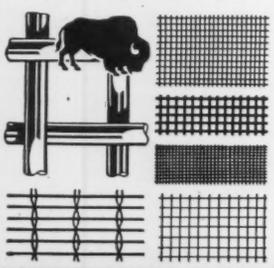
For correct wire cloth construction, notice if it is mercilessly beaten together or aptly woven. Note if it is fatigued, sprung beyond working limits. Look at the crimping...too little results in spreading, costly rescreening. Too much weakens screen, giving shorter service.



Write for Catalog:

Contains pages of help for the wire cloth buyer. Ask for catalog 11-H.

WIRE CLOTH BUYERS:
Send for Stock List of Wire Cloth for immediate shipment.

1

BUFFALO WIRE WORKS CO., Inc.
ESTABLISHED 1869 AS SCHEELER'S SONS

430 TERRACE BUFFALO, N. Y.

For a **LONG LIFE..** *..and carefree!*

RUTHMAN
GUSHER
COOLANT PUMPS

Not injured by small chips and grit. Strainers not necessary. No foot valves or relief valves. Larger ball bearings are used to insure more rigidity and longer life.

Many other Gusher features to help you speed work. A model for your requirements. Write!

Model P3

P-3 models are available in immersed type (1-P3), flange-mounted with internal discharge (2-P3), flange mounted with external right hand discharge (3-P3) left hand discharge (4-P3). All above are available in short and long models, that is, for two maximum high water lines.

THE RUTHMAN MACHINERY CO.
1811 READING ROAD, CINCINNATI, OHIO
LARGEST EXCLUSIVE BUILDERS OF COOLANT PUMPS

esting studies of rotating disks containing bolting holes.† Another discussion of photoelastic analysis of the stresses in rotating disks was prepared by R. E. Newton§. The photo in the first reference shows the high concentration produced at the bolting holes. Even though these holes are well within the inner boundary they may easily produce stresses exceeding those at the boundary, with the possibility of a failure crack radiating from the holes. It should be noted, though, that disks in general will be rotating continuously, or at least will have a relatively few number of speed variations. At the worst, the stresses alternate from zero to a maximum, never reversing. This condition gives a good opportunity for stress adjustment, and has probably saved from failure many a wheel overstressed by holes.

In the case of disks not of a rectangular section a fair approximation of stresses may sometimes be obtained by dividing the disk into a series of laminations, as shown in *Fig.* 105. The solution for more irregular shapes will be more complicated, and is not available for most cases. However, the data given in this article will usually permit of obtaining some idea of the magnitude of the stresses involved.

†*Metal Progress,* Feb. 1941.

§"A Photoelastic Study of Stresses in Rotating Disks," *Journal of Applied Mechanics,* 1940, pp. A57-A60.

Meetings and Expositions

Nov. 3-5—

American Institute of Chemical Engineers. Thirty-fourth annual meeting to be held at The Cavalier, Virginia Beach, Va. Additional information can be obtained from S. L. Tyler, 50 East Forty-second street, New York, executive secretary.

Nov. 12—

American Die Casting institute. Annual meeting to be held at Cleveland hotel, Cleveland. Kenneth C. Castleman, 420 Lexington avenue, Chicago, is secretary.

Dec. 1-3—

American Society of Agricultural Engineers. Semiannual meeting to be held at Stevens hotel, Chicago. Raymond Olney, St. Joseph, Mich., is secretary.

Dec. 1-6—

Exposition of Chemical Industries. Eighteenth exposition to be held at Grand Central Palace, New York. Additional information may be obtained from the International Exposition Co., Grand Central Palace, New York.

Jan. 12-16—

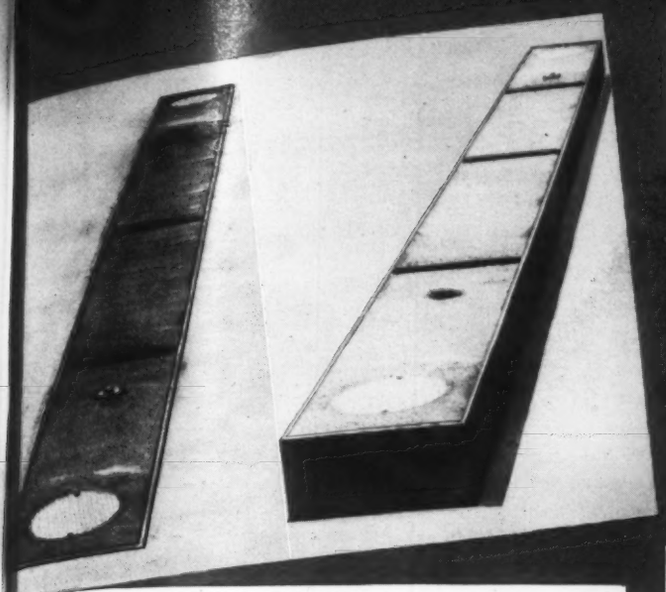
Society of Automotive Engineers. Annual meeting and engineering display to be held at Book Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

Jan. 12-15—

Coin Machine Industries Inc. Annual convention and show to be held at Hotel Sherman, Chicago. James A. Gilmore, 323 Sherman Hotel, Chicago, is secretary-manager.

HYCON

Makes 1 HP do the work of 100 HP



On some Hycon installations, such as this traffic fin, as much as 100 hp is supplied for 15 seconds by a Hycon storage tank operating in connection with a Hycon pump and a 1 hp motor. Other Hycon applications include the operation of brakes, clutches and steering devices on heavy vehicles . . . the control of machine tools . . . the testing of high pressure apparatus . . . and the actuation of remote control circuits.

HYCON Control System provides designers with a dependable means of using stored hydraulic energy (in working ranges up to 3000 psi) to control and actuate straight line motion.

One of the advantages this offers (illustrated by the application above) is power far in excess of the pump's capacity and independent of its operation. Others are: power insurance when the prime power source fails; the elimination of power waste involved in constant pumping; and the use of smaller motors or less costly power sources in applications requiring intermittent operation.

Important as these advantages are to today's emergency, they are no less vital to the era of industrial reconstruction which will follow. So if you face the problem of securing more positive, powerful or economical control over straight line motion mechanisms . . . get the full facts on Hycon now!

HYDRAULIC CONTROLS, INC.

(DIVISION OF THE NEW YORK AIR BRAKE COMPANY)

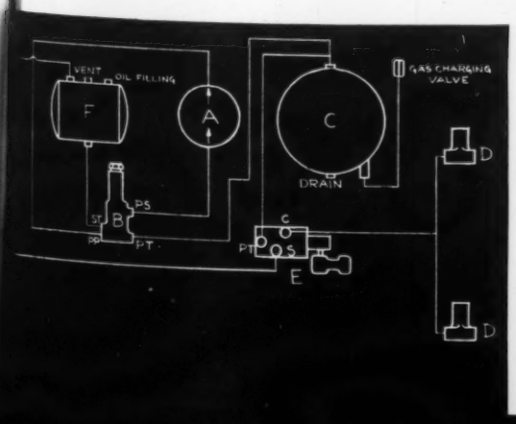
122 South Michigan Avenue, Chicago, Illinois, Dept. 106

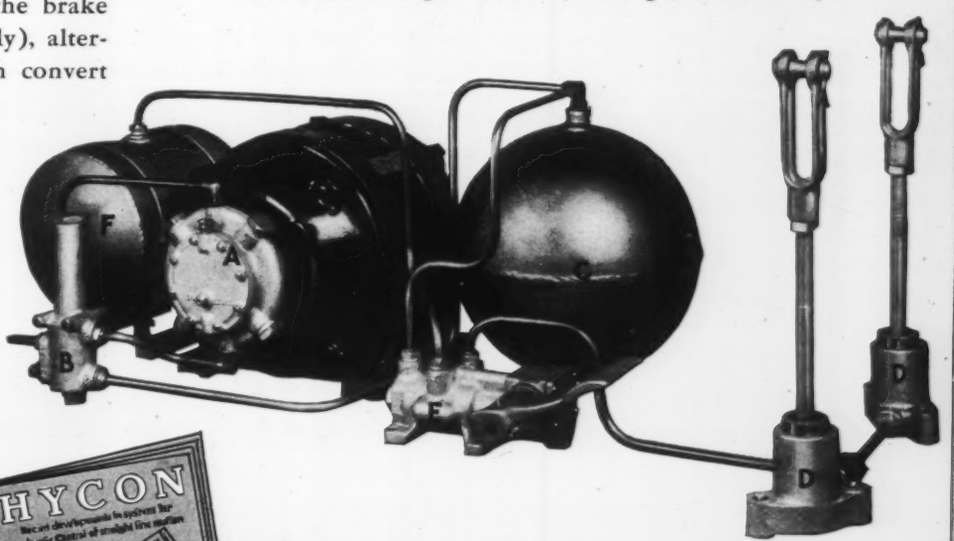
Functions of the Hycon System

typical hydraulic circuit is shown in relation to the illustra-on of the HYCON brake system using a motor driven pump. The pressure delivered by (A) the pump to (C) the pres-re tank *which acts as a storage battery for storing hydraulic ergy* is automatically regulated by (B) the suction con-ol valve.

This shuts off the intake to the pump when standard ressure is attained in the pressure tank; (E) the brake ontrol valve (actuated manually or automatically), alter-ately connects (D) the work cylinders (which convert ydraulic pressure into straight line action) to e pressure tank and to (F) the sump tank (which ollects fluid discharged by the work circuit for e-pumping to the storage tank).

The fluid thus delivered to the work circuit uilds up a pressure therein which is at all times trictly proportional to the movement and effort xerted on the valve lever.





Salient facts concerning the Hycon System have been condensed into a booklet titled, "Recent Developments in Systems for Hydraulic Control of Straight Line Motion." Please let us know where to send your copy.

Business and Sales Briefs

TWO more additions are being planned for construction by Ampco Metal Inc., Milwaukee. These are a machine shop addition and a forging shop. The new buildings will be constructed to the west of the present plant. This will be the eighth consecutive year in which an expansion program has been undertaken by the company.

♦

The Keystone Carbon Co., St. Mary's, Pa., has appointed A. T. Carter of 36 Richmond St., Rochester, N. Y. as its representative in upper New York state for its motor and generator brushes and negative temperature coefficient resistors.

♦

Having seen 17 years of service in the New York sales department of Handy & Harman, previous to five years in the Toronto office of the company, J. W. Colgan has been brought back to the New York office in the capacity of sales manager of the parent company.

♦

Ruthman Machinery Co., manufacturer of gusher coolant pumps, has moved into its large new plant and office, located at 1819 Reading road, Cincinnati. Output has increased 25 per cent during its first month's operation in the new building, and it is expected that during the second month the output will increase to 40 per cent.

♦

Formerly connected with Bendix Aviation Corp., South Bend, Ind., D. M. Watts will manage the Kaydon Engineering Corp., Lakeshore Drive, Muskegon, Mich., recently organized to manufacture special bearings for defense purposes.

♦

Plans for the construction of a plant to manufacture turbosuperchargers for airplanes are underway by General Electric Co., at Fort Wayne, Ind. At present this part is being manufactured at the Lynn, Mass. plant. The Everett, Mass., plant for similar manufacture is nearing completion. This latter is a "blackout" plant being completely windowless, and is, therefore, air conditioned.

♦

An addition to its factory on West Flournoy street, Chicago, has been announced by Ohmite Mfg. Co. Production space has been doubled.

♦

Announcement has been made by the SKF Industries Inc., of its new location at 1419 South Flower street, Los Angeles.

♦

District manager in the Houston territory for seven years, J. Walter Snavely has been transferred to the sales department of the conveying and engineering products division of Chain Belt Co., Milwaukee. W. A. Pitts, formerly representative in Oklahoma City, has been appointed district manager

Peerless
QUALITY MOTORS
Peerless is equipped to handle large or small orders in standard or special designs.
Every facility of our organization is at your command providing you with full cooperation and prompt action. Our expert engineering service guarantees you maximum efficiency, rugged design and trouble-free operation. Peerless has been building better motors for the past 48 years—always maintaining a quality and a performance unexcelled by any other motor.
THE PEERLESS ELECTRIC CO., WARREN, OHIO

FREE

AIR COMPRESSOR SELECTOR

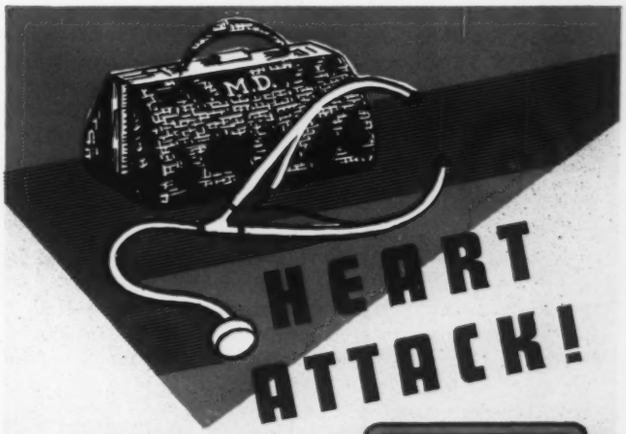
SELECT THE CORRECT SIZE AND TYPE AIR COMPRESSOR IN ONE MINUTE

This entirely new Compressor Selector works like a slide rule. One simple setting shows correct Compressor Model Number, free air delivery, r.p.m., piston displacement and horsepower motor required. Quick, accurate and dependable. For both air and water cooled compressor applications requiring up to 80 cu. ft. displacement. Pressures covered by the QUINCY Compressor Selector range from 30 to 250 lbs. per sq. in. ***WRITE TODAY*** for your FREE Compressor Selector. ***Supply is limited!***

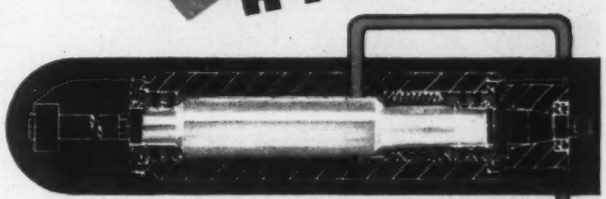
Quincy COMPRESSORS

QUINCY COMPRESSOR CO., 50 Main St., Quincy, Illinois

Branch Offices: New York • Chicago • San Francisco Cleveland • St. Louis



HEART ATTACK!

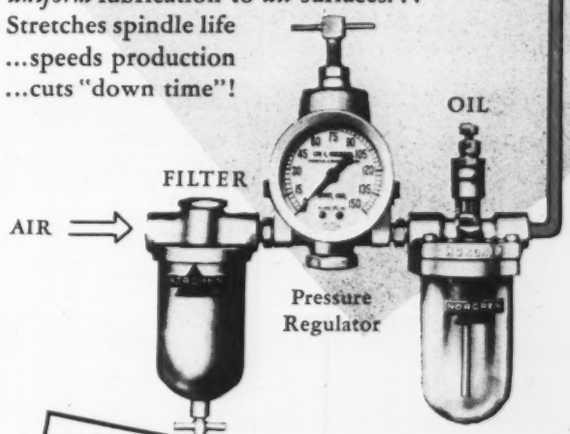


POSITIVE, engineered lubrication is the heart's blood of high speed spindles. And the Norgren (air) method of lubrication cuts all danger of "heart attack" to an irreducible minimum.

Moving as a fog of oil in cleaned air under mild pressure, lubricant COOLS as it OILS as it CLEANS . . . perfect lubrication even at spindle speeds hitherto thought impractical.

STOPS entry of coolants or abrasives . . . permits greater pre-loading...cancels the effect of centrifugal force on lubricant, bringing *uniform* lubrication to *all* surfaces. . .

Stretches spindle life
...speeds production
...cuts "down time"!



FREE DEMONSTRATIONS 30 days, or more if you wish, for any machine tool manufacturer who wants to beat yesterday's methods!

WHEREVER AIR IS USED IN INDUSTRY

C. A. Norgren Co.

211 Santa Fe Drive • DENVER, COLORADO

SEAL PROBLEMS?

ACME FLAT LAPPING SERVICE

Plus EXPERT ENGINEERING AID

AVAILABLE NOW . . . !

★ Where fluids and gases must be sealed in by moving parts, manufacturers know the importance of really tight seals. And, to assure themselves of better seal performance, many manufacturers are sending their rotating seals and valves to Acme for the final finishing process—lapping.

By a high precision, mechanized process, Acme lapping achieves perfectly mated sealing surfaces . . . lapped in production to within .000005" from absolute flatness. It offers all the advantages of skilled hand lapping at less cost. It also cuts assembly costs by eliminating re-assembly and retesting.

ACME SERVICE in the ACME PLANT!

Acme lapping service is available NOW, and Acme's engineers are ready to help you NOW . . . to improve your present seal, or design a complete new seal.

Moreover, Acme lapping done in the Acme plant releases *your* skilled help for other important duties.

Investigate Acme lapping and engineering service today. Send blueprints, or complete seal for specific recommendations.

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